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NEMO MODEL 2000 ACRYLIC PLASTIC SPHER-
ICAL HULL FOR MANNED SUBMERSIBLE OPER-
ATION AT DEPTHS TO 3000 FEET

Jerry D. Stachiw

Naval Undersea Center
San Diego, California

December 1974

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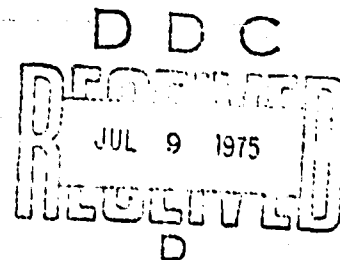


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AT DEPTHS TO 3000 FEET**

by

**Jerry D. Stachiw
OCEAN TECHNOLOGY DEPARTMENT**

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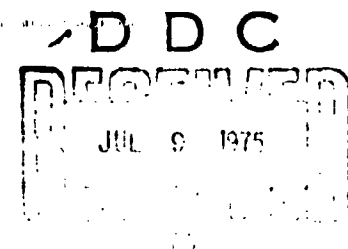
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Nemo Model 2000 Acrylic Plastic Spherical Hull for Manned Submersible Operation at Depths to 3000 Feet	CNM DLP	
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Plastics	Submersible Hulls	Transparent Materials
Structural Engineering	Acrylic Hull	Pressure Hulls
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<p>Nemo Model 2000 acrylic plastic pressure hull assembly is described and represents the latest addition to the Nemo hull series represented by Nemo Model 600 and 1000 hull assemblies. The 66 inch OD x 58 inch ID spherical acrylic hull with aluminum hatches has successfully withstood 24 hour long external hydrostatic pressurizations to 450, 900, 1350 and 1800 psi. Pressure cycling and short term destructive testing of 15 inch OD x 13 inch ID scale models has shown that the crackfree fatigue life is in excess</p>		

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of 1000 pressure cycles at depths to 3000 feet and the short term implosion pressure is in the range of 10,000 to 11,000 feet. Stress wave emissions have been found to be a good indicator of incipient failure.

Nemo Model 2000 spherical pressure hulls with panoramic visibility are considered to be acceptable for manned submersibles with an operational depth capability to 3000 feet. The cyclic fatigue life of such hulls is conservatively predicted to be at least 12×10^6 feet hours.

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SUMMARY

Problem

Manned submersibles with spherical acrylic plastic hulls have been known since the conception of the Nemo Hull in 1961 to provide greater panoramic vision at lower cost than steel hulls of the same shape and size equipped with many small portholes. To utilize this concept in Fleet design, the Nemo Hull was officially approved for minimum depth dives to 600 feet and demonstrated capabilities to 1000 feet in 1971. To further benefit Fleet operation, design and fabrication techniques were required to ameliorate fatigue factors inherent to structural joints between plastic and metal parts and thereby achieve the maximum operating depth allowed by the physical properties of acrylic plastic.

Results

Successive technological innovations have yielded three Nemo Hull designs that can be incorporated into existing or planned submersible systems for certified man-rated operation to ocean depths of 1000, 2000, and 3000 feet. New hatch design details have decreased bending moments at metallic hatch acrylic hull interface and the use of polycarbonate gaskets in the acrylic plastic hatch seat has eliminated shear cracking. The latest of the Nemo Hull series, Model 2000, has a 66-inch outside diameter and a 58-inch inside diameter that yields a fatigue life of 12,000,000 feet hours over a projected 10-year life span and is capable of operation to the maximum depth allowed by the properties of acrylic plastic.

Recommendations

The Model 2000 Nemo Hull is recommended for manned operation at depths to 3000 feet. This latest design can now provide the Navy with a transparent hull for a wide variety of applications in undersea warfare, search, salvage, surveillance, and recovery missions.

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DEFINITION OF TERMS

ASTM	American Society for Testing of Materials
critical pressure	external hydrostatic pressure at which catastrophic failure of the pressure hull takes place
ft	feet; equals 30.48 cm
hoop stress	principal membrane stress oriented at right angles to the longitudinal stress
ID	inside diameter of acrylic sphere
in	inches; equals 2.54 centimeters
longitudinal stress	principal membrane stress whose direction passes through poles of the sphere
NCEL	Naval Civil Engineering Laboratory, Port Hueneme, CA
Nemo Hull	Acrylic plastic hull with one atmosphere interior for manned submersibles with the following primary characteristics: (1) spherical shape (2) modular assembly of bonded pentagons (3) polar openings closed by inserts, a hatch at the top and a plate at the bottom (4) bearing surfaces on metallic hatch form a spherical angle whose apex is at the sphere
OD	outside diameter of acrylic sphere
PMR	Pacific Missile Range, Point Mugu, CA
psi	pounds per square inch; equals 0.070 kg cm^{-2}
R_i	inside diameter of acrylic sphere
R_o	outside diameter of acrylic sphere
short-term pressure	pressurization at 100 psi/minute rate
t	thickness of acrylic sphere

INTRODUCTION

The idea of transparent pressure hulls for manned submersible operation became a reality in 1968 with the successful fabrication of the first full scale Nemo Hull shown in Figure 1. Since then, acrylic plastic pressure hulls of spherical shape have demonstrated competitive cost, unsurpassed panoramic visibility, and a large depth safety margin, which has given the Navy a cost-effective solution to submersible hull design.

Testing and evaluation of models and full scale Nemo Hulls continued until in 1970 the Model 600 Nemo Hull was officially approved by the U. S. Navy for manned operation to 600 feet,¹ although it demonstrated capabilities to 1000 feet, as pictured in operation in Figure 2. At that time, Nemo's endurance range beyond the standard 1000-foot minimum was inhibited by stress limitations inherent to joints between the acrylic hull and metallic hatches.²⁻⁵ Further design studies were initiated to relieve this fatigue factor and extend the depth limit of the Nemo Hull to the maximum allowed by physical properties of the material for future work in deep ocean environments.

Subsequent work efforts during 1971-1972 resulted in the Model 1000 Nemo Hull with an optimized aluminum hatch and aluminum seating ring assembly. This model has been designed and stress analyzed for safe operations to 2000 feet. Both Models 600 and 1000 Nemo Hulls are recommended as cost-effective transparent hulls for submersible operations to, respectively, 1000 and 2000 feet.

The apex of development for the Nemo Hull culminated in 1974 with the Model 2000, the presentation of which is the purpose of this report. The results of experimental and analytical studies are presented for this acrylic plastic pressure hull, which is capable of manned submersible operation at depths to 3000 feet for at least 1000 times without fatigue cracks. The Model 2000 Nemo Hull provides the maximum safe operational depth with minimum weight to displacement and cost depth ratios for use with manned submersibles in undersea warfare, search, salvage, surveillance and recovery missions to 3000 feet.

New design techniques and fabrication procedures are presented along with documented test results. The main body of the report is concise but terse to afford the reader a summary of study highlights. A more detailed description of design studies, fabrication procedures, and hydrostatic tests are presented in, respectively, Appendixes A, B, C, and D. The report documents a major breakthrough in technology for submersible hulls with panoramic visibility.

BACKGROUND

The failure of an acrylic plastic spherical Nemo Hull can occur in three ways. The hull can implode instantaneously because of overpressurization accompanying the catastrophic loss of the depth control system on a submersible; this type of failure is classified as *short term failure* and the pressure at which the failure occurs as short term critical pressure. The hull can also implode after it has been subjected for a long period of time to a

depth, which is greater than the operational pressure, but less than the short term critical pressure. This type of failure is classified as *long term creep failure*. Finally, the failure of the hull can be initiated by cracks resulting from repeated dives to operational depth; this type of failure is classified as *fatigue failure*.

Previous experimental studies have already generated the data for prediction of short term and long term creep failures in Nemo Hulls with t/D_o ratios in the 0.015-0.017, 0.03, 0.047-0.05 and 0.064-0.07 ranges.⁶ In conjunction with short term and long term implosion studies some data was also generated on the initiation of fatigue cracks in the acrylic bearing surfaces for metallic hatches on hulls with t/D_o ratios in the 0.03-0.035 range (references 2, 3, 4, 5). On the basis of that data it was concluded that for all practical applications in acrylic plastic Nemo Hulls the operational depth limitation is imposed primarily by the fatigue life of acrylic bearing surfaces supporting the metallic hatch. It is this fatigue life that imposes the 1000-foot operational depth limit on the 2.5-inch thick Model 600 Nemo Hull assembly and the 2000-foot limit on the nominally 4-inch thick Model 1000 Nemo Hull; the fatigue life being in both cases 1000 dives of 4 hour duration each to the maximum operational depth without initiation of fatigue cracks.

Since the short term collapse depth of the nominally 2.5-inch thick hull is 4150 feet and of the nominally 4-inch thick hull is 10,000 feet, there was no doubt that there existed a sufficient reservoir of potential structural strength to warrant research on improving the fatigue life of the hatch-hull interface. The effort to improve the fatigue life of Nemo Hulls was focused primarily on the Model 1000 Nemo Hull with a nominal 4-inch wall thickness,⁷ as the potential operational depth improvement appeared to be higher here than in the Model 600 Nemo Hull with a nominal 2.5-inch thickness.

DISCUSSION

The objective of the study was to maximize the operational depth of the 66-inch diameter Nemo Hull with a 4-inch nominal wall thickness and maintain the minimum 1000 cycle fatigue life requirement specified for all acrylic plastic hulls.^{5,6}

The approach selected was to (1) redesign the top and bottom aluminum inserts, (2) redesign the interface between the insert and the hull, and (3) improve the fabrication process for the hull. All of the modifications to the Nemo Hull design were to be evaluated experimentally and analytically.

The scope was to limit the study to two acrylic hull sizes: the 66-inch diameter, 4-inch thick, full scale operational hull and the 15-inch diameter, 1-inch thick model scale hull. The cyclic fatigue tests and the short term implosion tests were performed on the 15-inch diameter model scale hulls while the experimental determination of stress distribution and comparison with analytical stress calculations were conducted on the 66-inch diameter full scale operational hull.

DESIGN OF POLAR INSERTS

Although the existing design for polar inserts in the 66-inch diameter, nominally 4-inch thick Model 1000 Nemo Hull incorporated on the JOHNSON SEA-LINK submersible⁷ was satisfactorily tested to a proof test of 2000 feet, without yielding and probably could be used to greater depths, it contained a large number of undesirably high stress concentrations and thus was considered questionable for 3000-foot service. For a minimal cost, these hatches were modified for safe operation to 3000 feet.

The redesign of existing aluminum polar inserts for the 66-inch diameter, 4-inch thick hull currently in service with the JOHNSON SEA-LINK submersible; see Ref. 7) consisted of redistributing the metal in the hatch and penetration plate so that the resultant of compressive membrane stresses in the acrylic hull would pass as close as possible to the centroid of the insert and thus generate only moderate bending moments in the insert; see Figure 3. A more detailed description of system design including schematic drawings is presented in Appendix A.

The new hull assembly was stress analyzed utilizing the finite element stress analysis program for arbitrary axisymmetric structures, called ZP-13,⁸ as illustrated in Figure 4.

For this program the top hatch was idealized into 244 nodes and 399 elements, as shown in Figure 5, while the bottom plate was idealized into 228 nodes and 367 elements, shown in Figure 6. The maximum stresses in the aluminum hatch and bottom plate were calculated to occur at the central penetrations and at the junctions between the spherical aluminum shells and the circular flanges (again see Figs. 5 and 6). The highest stress in the plastic hull was predicted to occur on the interior surface at the point of contact between the aluminum flanges and the polycarbonate gasket.

The magnitude of the peak principal stresses in the top and bottom aluminum inserts when operating at a depth of 3000 feet was predicted to be 24,250 and 25,400 psi, respectively (values derived from extrapolation of stresses shown in Figs. 5 and 6). In both cases the peak principal stresses were located on the inside of the central hatch penetrations. These peak compressive hoop stresses were not considered dangerous at that location since the steel bulkhead penetrators would serve as reinforcements and carry some of the compressive stresses. The stresses at the juncture between the spherical surfaces on the hatch and bottom plate and their flanges were also substantial (20,000-23,000 psi), but they were well below the yielding point of aluminum. From an extrapolation of the stress values shown in Figures 7 and 8, the maximum compressive stress in the plastic hull was predicted to be longitudinal and of 10,900 psi magnitude. These stress levels were considered acceptable for operation of the manned Model 2000 Nemo Hull submersible to 3000 feet since the associated calculated safety factors, based on yielding of the aluminum and acrylic plastic, were approximately 1.5 for both materials.

DESIGN OF INSERT/HULL INTERFACE

The insert/hull interface successfully utilized in existing acrylic plastic submersibles NEMO, MAKAKAI, and JOHNSON SEA-LINK #1, consisted of direct contact between the metallic insert flange and the acrylic plastic.^{2,9-11} Since the orientation of the interface was radial, shear stresses were minimized. Still, because of differences in structural rigidity

between the metallic inserts and the plastic hull, some differential movement between the inserts and the acrylic hull, as well as bending of the hull, takes place which causes shear cracks to appear in those areas of the acrylic plastic that come in contact with the metallic inserts.

There were two options available for elimination of the shear cracks. One feasible approach was to replace the metallic inserts with discs made of acrylic plastic with the same rigidity and compressibility as the plastic hull. The other approach was to place a compliant gasket between the rigid metallic insert and the limber plastic hull. Of these two approaches, the use of gaskets was operationally more appealing as it allowed the retention of operationally proven metallic inserts with the desirable high heat transfer coefficients. This left only the selection of the right type and thickness of gasket.

The gasket finally selected for the Model 2000 Nemo Hull assembly was one-inch thick polycarbonate plastic (see Fig. 3, Appendix A). Polycarbonate plastic was chosen because of its toughness, resistance to crack propagation, and modulus of elasticity that matches that of acrylic plastic. Because of the 1-inch wall thickness, the gasket possessed sufficient inherent structural strength to prevent it from being extruded into the hull interior by outside hydrostatic pressure. Also, the circumferential flange on the exterior edge of the gasket serves as a seal retainer, which keeps the water from entering the joint between the polycarbonate gasket and the acrylic plastic hull. The seal consisted of room temperature vulcanizing silicone rubber dispensed from a tube into the space between the gasket flange and the acrylic hull.

IMPROVEMENT OF FABRICATION PROCESS

The fabrication process^{1,2} developed for the first acrylic plastic Nemo submersible¹ was also used in the fabrication of the acrylic plastic hulls for MAKAKAI¹⁰ and the JOINSON SEA-LINK⁷ and focused primarily on the attainment of tight dimensional tolerances for the sphericity of the hull exterior. The variation in thickness of individual spherical pentagon modules remained a function of commercial casting tolerances for individual plates. Because of this dependency, the thickness of individual spherical pentagons varied as much as ± 0.250 of an inch.

The large variation in thickness was acceptable so long as it was economically acceptable to rate the operational depth capability of a Nemo Hull on the basis of minimum hull thickness, and the mismatch in thickness between individual spherical pentagons was not considered optically objectionable. However, when emphasis was placed on cost effectiveness of the acrylic hull as a structure and as an optical system, it became economically untenable to tolerate such a large variation in wall thickness. The thicker portions of the hull would have constituted additional ballast that detracted from the payload and added nothing to the depth capability. In addition, the mismatches in thickness between individual spherical pentagons would have created a noticeable optical distortion for the crew of the vehicle.

Obviously, the key to uniformity of wall thickness was to use thick acrylic plastic spherical pentagons of uniform thickness in the construction of the hull. Basically, there were three techniques available for attainment of uniformly thick spherical pentagons: (1) custom casting of acrylic plates to very tight dimensional tolerances, (2) grinding

off-the-shelf acrylic plates to a uniform thickness, and (3) grinding spherical sectors to uniform curvature and thickness after thermoforming of plates. Of these three techniques the last one was found to produce the smallest thickness variation at approximately the same or less cost than required by the other techniques. The tolerances on hull thickness attained by grinding of formed spherical sectors were ± 0.050 inches.

FABRICATION

Full Scale Assembly

Acrylic Hull

The 66-inch OD \times 58-inch ID Model 2000 acrylic plastic Nemo Hull (see Figs. 9 and 10) was fabricated by Swedlow, Inc., basically in the same manner as the previously built Nemo Hulls.^{1,2,13} The only improvements over the previous fabrication technique were the contour grinding of formed spherical sectors and placement of adhesive into the joints between spherical pentagons by means of hydrostatic pressure. Fabrication techniques, dimensional drawings, and relevant contract correspondence are presented in Appendix B.

Acrylite[®] plates manufactured by Monsanto served as basic construction material. The stringent material quality control procedures developed by NCEL and PMR for the prototype Model 600 Nemo Hull were applied here also.² Testing of material specimens showed that the 4.125 nominally thick Acrylite met the physical properties criteria listed in Table 1, as established by the Navy for acrylic plastic windows and pressure hulls in manned service.²⁻⁵

Because of improved fabrication techniques, not as many dimensional tolerances were required in building the Model 2000 Nemo Hull as were required for the Model 1000 Nemo Hull fabricated for the JOHNSON SEA-LINK submersible.⁷ Thus, whereas the Model 1000 Nemo Hull thickness varied from 3.844 to 4.030 inches, the Model 2000 Nemo Hull varied only from 4.000 to 4.100 inches. Similarly, whereas the sphericity of Model 1000 Nemo Hull varied from 66,250 to 65,800, the Model 2000 Nemo Hull varied only from 66,095 to 65,900 inches. Assembly dimensions for the Nemo Model 2000 are listed in Table 2.

The only area that did not realize a significant improvement in the fabrication process was the bonding of joints between individual pentagons. A comparison of the 5456 to 7804 psi bond strength achieved for the 4-inch thick Model 1000 Nemo Hull⁷ with that of the 5123 to 9116 psi bond strength attained for the Model 2000 Nemo Hull indicates that the strength of bonded joints in both hulls is about the same. This holds true also for the quality of the joint. Both the number and size of inclusions was about the same as shown in Figure 11 a and b. This indicates that although the technique of emplacing the adhesive into the joint and the polymerization regimen have been drastically changed since the fabrication of the first Model 600 Nemo Hull in 1968,² the performance of the bonded joint has not. Since the entire Nemo Hull is under compression when submerged to operational depth, very little incentive exists to effect further improvements in the tensile qualities of the joints.

**Table 1. Physical Properties of Acrylic Plastic Hull
for 66 Inch OD X 58 Inch ID Nemo Model 2000**

	<i>Minimum</i>	<i>Average</i>	<i>Maximum</i>
1. Properties of Plastic*			
<u>ASTM D-638</u>			
Ultimate Tensile Strength, psi	9,545	10,972	12,331
Elongation, percent	3.0	5.291	7.0
Modulus of Elasticity, psi	428,000	465,583	505,000
<u>ASTM D-790</u>			
Ultimate Flexural, psi	15,238	17,736	18,686
Modulus of Elasticity, psi	415,000	463,125	487,000
<u>ASTM D-732</u>			
Ultimate Shear Strength, psi	9,880	10,088	11,500
<u>ASTM D-695</u>			
Compressive yield, psi	17,700	18,416	19,600
Compressive modulus, psi	500,000	520,416	570,000
<u>ASTM D-621</u>			
Deformation under load: 4000 psi, 122° F for 24 hours	0.42	0.55	0.72
2. Properties of bonded joints**			
<u>ASTM D-638</u>			
Ultimate tensile strength, psi	5,123	7,815	9,116

*Total of 120 specimens taken from 12 acrylic plastic plates with 4.125 X 48 X 60 inches nominal dimensions.

**Total of 12 specimens taken from test blocks bonded for quality control purpose.

**Table 2. Dimensions of the 66 Inch OD x 58 Inch ID Hull
for Nemo Model 2000 Assembly**

1. Individual Pentagons				
Pentagon	Thickness*		Contour Deviation**	
	Maximum	Minimum	Maximum	Minimum
A	4.070	4.035	0.075	0.005
B	4.075	4.040	0.070	0.010
C	4.070	4.020	0.070	0.010
D	4.100	4.050	0.100	0.030
E	4.070	4.050	0.070	0.010
F	4.110	4.005	0.040	0.020
G	4.060	4.030	0.150	0.050
H	4.065	4.010	0.100	0.020
I	4.090	4.060	0.100	0.010
J	4.070	4.050	0.100	0.020
K	4.050	4.000	0.100	0.020
L	4.030	4.000	0.090	0.010
2. Sphere Assembly				
Spherical Deviations		Maximum	Minimum	
Total of 5 Measurements		0.100	+0.095	
<hr/>				
*Total of 6 measurements per pentagon				
**Total of 5 measurements per pentagon				

Metallic Polar Inserts

The top hatch, top hatch ring, and bottom plate for the 66-inch OD hull were fabricated by machining 6061-T6 aluminum forgings, as pictured in Figures 12a, b and 13a, b (also see Appendix B). Material quality control of the aluminum forgings indicated a compressive yield strength of 36,300 psi and ultimate compressive strength of 43,100 psi. Special attention was paid to the machining of beveled seal seating surfaces to assure positive sealing and good bearing contact.

Polycarbonate Bearing Gasket

The bearing gaskets shown in Figure 14 between the metallic polar inserts and acrylic plastic hull were machined from polycarbonate plastic plates. Material quality control of the polycarbonate plates used as machining stock showed that the material was acceptable for this application. The physical properties are summarized in Table 3.

Table 3. Physical Properties of Polycarbonate Plastic Gaskets
for 66 Inch OD x 58 Inch ID of Nemo Model 2000

	<i>Minimum</i>	<i>Average</i>	<i>Maximum</i>
<u>ASTM D-638</u>			
Ultimate Tensile Strength, psi	6,640	7,170	7,690
Elongation, percent	2.3	2.6	2.8
Modulus of Elasticity, psi	320,000	320,000	320,000
<u>ASTM D-790</u>			
Ultimate Flexural, psi	11,700	11,900	12,000
<u>ASTM D-732</u>			
Ultimate shear strength, psi	10,400	10,400	10,400
<u>ASTM D-695</u>			
Compressive yield, psi	12,500	12,800	13,000
Compressive modulus, psi	360,000	370,000	380,000
<u>ASTM D-621</u>			
Deformation under load, percent 4000 psi, 122 °F for 24 hours	0.12	0.13	0.14
<u>ASTM D-256</u>			
Izod impact strength	0.67	0.76	0.85
<u>ASTM D-570</u>			
Water absorption, percent 24 hours	0.14	0.15	0.15

Since a polycarbonate plate of 6-inch thickness is currently not fabricated by industry, several half-inch thick plates were bonded together to form a 6-inch thick block. Although the bonding was performed by General Electric, the developer of polycarbonate plastic, the quality and strength of the joints were less than of the parent material. Additional efforts by Southwest Research Institute (SWRI) were made to improve the bonding technique, although these too failed to yield perfect joints. However, in view of the fact that the gasket is in compression when incorporated into the Model 2000 Nemo Hull assembly, less than perfect bonded joints were considered as acceptable for compressive loading service.

Scale Model Assembly

Acrylic Hull

The 15-inch OD \times 13-inch ID acrylic plastic hulls were fabricated by the Technical Support Department of the Pacific Missile Range; Figure 15 pictures one of these hulls. The same thermoforming, machining, and bonding techniques were used to fabricate this scale model as were used in the fabrication of prototype models developed for the Nemo research program in 1965.² Quality control of acrylic plastic and of bonded joints showed that the scale model materials met the same specifications as did the full scale 66-inch diameter hull. Four scale models have been fabricated.

Metallic Polar Inserts

The polar inserts for the 15-inch OD model scale hulls were fabricated by machining aluminum and titanium forgings (see Appendix A). The 6061-T6 aluminum inserts were structural scale models of the aluminum polar inserts in the 66-inch diameter hull; see Figures 16a, b and 17a, b. The Ti-6Al-4V titanium inserts shown in Figure 18a, b, c, d represented simplified scale models of an alternate design for the 66-inch OD hull polar inserts, except that titanium was utilized instead of aluminum.

Polycarbonate Bearing Gaskets

The polycarbonate bearing gaskets (see Appendix A) were machined from 1-inch thick polycarbonate plates (Lexan CP-438). Common machine shop practices were used to achieve the desired finish and tolerances.

TEST PROGRAM

Model Scale Hulls

Static Tests

One 15-inch OD \times 13-inch ID scale model hull, shown in Figure 19, was subjected to a series of hydrostatic tests which culminated in the implosion of the hull. The objectives of the static tests were to (1) establish the validity of aluminum hatch design for ocean depth operation to 3000 feet, (2) measure the stress wave emissions of the acrylic hull, (3) measure the creep of the hull at depths to 3000 feet, and (4) determine the short term implosion depth of the Model 2000 Nemo Hull assembly. To accomplish these objectives the scale model of the Model 2000 Nemo Hull was instrumented with 10 electric resistance strain gages and an acoustic transducer with a 160 kHz response capability, as shown in Figure 20.

Static tests were conducted at a room temperature range between 70-75 °F in the pressure test facilities of the Southwest Research Institute, San Antonio, Texas.

1. Pressurize the 15-inch OD \times 13-inch ID Nemo Model 34 to 1350 psi at 100 psi/minute rate, hold for 4 hours at that pressure, depressurize at 100 psi/minute rate to 0 psi, allow to relax for 4 hours prior to next test.
2. Pressurize the 15-inch OD \times 13-inch ID Nemo Model 34 to 900 psi at 100 psi/minute rate, hold for 4 hours at that pressure, depressurize at 100 psi/minute rate to 0 psi, allow to relax for 4 hours prior to next test.
3. Pressurize the 15-inch OD \times 13-inch ID Nemo Model 34 to implosion at 100 psi/minute rate.

Cyclic Tests

Three 15-inch OD \times 13-inch ID Nemo Hull scale models were subjected to a series of pressure cycling tests. The objective of the pressure cycling tests was to establish (1) the fatigue life of bearing surfaces in acrylic plastic hulls that are in direct contact with metallic polar inserts and (2) the fatigue life of bearing surfaces in acrylic plastic hulls that are not in direct contact with the metallic polar inserts but interface through a polycarbonate bearing gasket; an assembly drawing of these contact points is shown in Figure 21. To achieve these objectives, the bearing surfaces of the acrylic hulls were to be inspected at the conclusion of the pressure cycle tests.

Pressure cycling of the scale model consisted of a series of tests conducted at a room temperature range between 70-75 °F in the pressure test facilities of the Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California, performed as follows.

1. Pressurize the 15-inch OD \times 13-inch ID Nemo Model No. 35 to 500 psi at 100 psi/minute rate; hold at this pressure for 4 hours; depressurize at 100 psi/minute rate to zero and relax at that pressure for 4 hours before initiating the next pressure cycle. Repeat the pressure cycle 1000 times.

2. Pressurize the 15-inch OD \times 13-inch ID Nemo Model No. 36 to 1000 psi at 100 psi/minute rate; hold at this pressure for 4 hours; depressurize at 100 psi/minute rate to zero and relax at that pressure for 4 hours before initiating the next pressure cycle. Repeat the pressure cycle 1000 times.
3. Pressurize the 15-inch OD \times 13-inch ID Nemo Model No. 37 to 1500 psi at 100 psi/minute rate; hold at this pressure for 4 hours; depressurize at 100 psi/minute rate to zero and relax at this pressure for 4 hours before initiating the next pressure cycle. Repeat the pressure cycle 1000 times.

Full Scale Hull

Static Tests

The 66-inch OD \times 58-inch ID full scale Model 2000 Nemo Hull assembly was subjected to a series of hydrostatic tests at SWRI, which culminated with a 4000-foot depth proof test. Figure 22 pictures the Model 2000 Nemo Hull with the SWRI pressure vessel. The objectives of the static tests were to (1) establish experimentally the strains and stresses imposed on the Model 2000 Nemo Hull assembly at a 3000-foot operational depth for comparison with the analytically generated data and (2) prove that the full scale Model 2000 Nemo Hull assembly could withstand pressures to a depth of 3000 feet without permanent deformation. To accomplish these objectives, strains were to be recorded during all of the tests at 20 locations; the location of the strain gages on the Model 2000 Nemo Hull is shown in Figure 23.

The static test series consisted of the following tests conducted at a room temperature which ranged between 65-75 °F in the pressure test facilities of the Southwest Research Institute, San Antonio, Texas:

1. Pressurize to 450 psi at 100 psi/minute rate, hold at that pressure for 24 hours, depressurize to 0 psi at 100 psi/minute rate, and relax at that pressure for 24 hours prior to beginning of next test.
2. Pressurize to 900 psi at 100 psi/minute rate, hold at that pressure for 24 hours, depressurize to 0 psi at 100 psi/minute rate, and relax at that pressure for 24 hours prior to beginning of next test.
3. Pressurize to 1350 psi at 100 psi/minute rate, hold at that pressure for 24 hours, depressurize to 0 psi at 100 psi/minute rate, and relax at that pressure for 24 hours prior to beginning of next test.
4. Pressurize to 1800 psi at 100 psi/minute rate, hold at that pressure for 24 hours, depressurize to 0 psi at 100 psi/minute rate, and relax at that pressure for 24 hours prior to beginning of next test.

No cyclic tests were performed on the full scale Model 2000 Nemo Hull assembly.

TEST OBSERVATIONS

Model Scale Tests

Stresses

The 15-inch OD \times 13-inch ID Nemo Model 34 assembly performed satisfactorily at simulated depths to 3000 feet. The highest measured principal stress of ~ 5086 psi in the acrylic hull was on the interior, located at the edge of the top polar opening (0.500 inches away from aluminum hatch) and orientated along the meridian of the sphere; recorded stress values are listed in Table 4 (also see Figure 19). It is worth noting, however, that its magnitude was approximately only 10 percent larger than the average stress of ~ 4642 psi measured at the equator on the interior of the sphere. This can be explained by the fact that the stress riser effect of the metallic insert decays rapidly with distance from the hatch. Since the strain gage was located approximately 3 degrees away from the edge it did not measure the peak stress but rather the tail end of it.

The maximum stress of $\sim 15,714$ psi in the polar aluminum inserts was measured on the inside surface, adjacent to the flange, in the bottom plate, and its orientation was in the longitudinal direction.

The highest measured stresses, both on the acrylic hull and the aluminum inserts during the simulated dive to 3000 feet, were well below the yield points of their respective materials. All strains were observed to return to zero upon completion of the relaxation period following the simulated dive to 3000 feet (see Table 4). For both the acrylic plastic and aluminum, the apparent safety factors, based on the short term yielding of material, were well in excess of 2. On the basis of these stress measurements it was concluded that (1) the proposed design of hatches was adequate for dives to 3000 feet and that (2) the whole full scale Model 2000 Nemo Hull assembly could be safely tested at least at depths to 3000 feet.

Implosion Resistance

The 15-inch OD \times 13-inch ID Model 34 Nemo Hull imploded under short term pressure loading at a simulated depth of 10,600 feet. The assembly failed by general plastic instability; the fragmented model is shown in Figure 24. The highest measured stresses in the aluminum hatches, prior to implosion, were found to be at locations #4 and #7 (see Figure 19), and their magnitude was in the $\sim 35,000$ to $\sim 39,000$ psi range, as shown in Figure 25. The 10,600-foot short term implosion depth of Model 34 gives the scale model a 3.5 safety margin for catastrophic dives. Data reduction of the hydrostatic tests is documented in Appendix C.

Acoustic Emission

The 15-inch OD \times 13-inch ID Model 34 was a good source of acoustic emission during the first pressurization to 1350 psi; Figure 26 presented a histogram of stress wave

Table 4. Strains in 15 Inch OD x 13 Inch ID Nemo Model #34
during Simulated Dive at Depths to 3000 Feet

No.	Gages Location		Strain micro inches/inch		Stress (psi)	
			Hoop	Longitudinal	Hoop	Longitudinal
1a	Equator, outside	A	-5,900*	-5,700*	-3,345*	-3,284*
		B	-6,700	-6,300		
		C	0	-100		
1b	Equator, inside	A	-8,200*	-8,000*	-4,681*	-4,604*
		B	-9,550	-8,900		
		C	+10	+25		
2b	Edge of top polar opening, inside	A	-6,900*	-9,500*	-4,286*	-5,086*
		B	-7,700	-1,100		
		C	-50	-100		
3b	Lip of flange, bottom plate; inside	A	-900*	+150*	-9,386*	-1,319*
		B	-900	+150		
		C	0	0		
4a	Root of flange, bottom plate; outside	A	-275*	-50*	-3,187*	-1,456*
		B	-275	+100		
		C	0	0		
4b	Root of flange, bottom plate; inside	A	-600*	-1,250*	-10,714*	-15,714*
		B	-700	-1,350		
		C	0	0		
5a	Root flange, top hatch, outside	A	-100*	malfunc-	-1,099*	-330*
		B	-100	tioning		
		C	0	s. gage 0		
5b	Root of flange, top hatch, inside	A	-1,100*	-200*	-12,747*	-5,824*
		B	-1,100	-200		
		C	0	0		
6b	Edge of bottom, polar opening, inside	A	-8,300*	-6,900*	-4,558*	-4,127*
		B	-9,200	-7,800		
		C	0	+250		
7b	Lip of flange, top hatch, inside	A	-1,300*	+300*	-13,297*	-989*
		B	-1,300	+300		
		C	0	0		

Note A*: Immediately after pressurization to 3000 foot depth
B. After four (4) hours at 3000 foot depth
C. After 16 hours of relaxation at 0 depth

emissions. When, after relaxation at 0 psi, Model 34 was pressurized to 900 psi no further acoustic emission bursts were recorded which indicated that the acrylic hull exhibits a very marked Kaiser effect.

During the final pressure test to implosion, Model 34 emitted significant numbers of acoustic emissions, although only after the pressure passed the 9500-foot depth mark. Thus, between 0 and 9500 feet there were less than 50 emissions, as shown in Figure 27. Obviously then, the impending implosion of the acrylic hull could have been stopped during the simulated dive at about 500 feet above implosion depth on the basis of the acoustic emission recording (see Fig. 26).

Cyclic Fatigue Crazing

Observation of 15-inch OD \times 13-inch ID Models 35, 36 and 37, after 1000 simulated 4-hour long dives, shown in Figure 28, revealed that only Model 37 which was pressure cycled to a depth of 3360 feet had slight indication of cyclic fatigue, whereas Models 35 and 36 which were pressure cycled to, respectively, 1120 and 2240 feet showed no signs of cyclic fatigue. The cyclic fatigue in Model 37 exhibited slight crazing of its conical bearing surface in the polar opening of the acrylic hull, which was exposed to direct contact with the metallic insert, see Figure 29. The other polar opening in Model 37, in which the acrylic bearing surface was not in direct contact with the metallic insert did not craze. From this, it can be concluded that at a cyclic history of less than 1000 dives the polycarbonate gasket has a significant effect only when the maximum pressure in a dive is 3360 feet or more. At lesser depths the polycarbonate gasket also increases the fatigue life of the acrylic hull, although more than 1000 dives are required to show experimentally the beneficial effect of the polycarbonate gasket.

It is important to point out here that even in Model 37 which was the only specimen with signs of cyclic fatigue on the acrylic bearing surface, the fatigue exhibited itself in the form of barely noticeable crazing. Based on past experience,⁵ it can be conservatively predicted that it would take at least another 1000 dives to 3360 feet before the crazing would deteriorate into cracks 1/2-inch deep and thus require remachining of the bearing surface.

Creep

The creep observed during 4-hour sustained loading to 1350 psi was significantly higher than during sustained loading to 900 psi, as shown in Figures 30 and 31. The magnitude of creep in both cases was about 15 percent of short term strain. As expected (magnitude of creep is a function not only of time but also of short term strain), creep was more substantial at the edges of polar openings than at the equator. Similarly, it was larger on the interior of the hull than on its exterior.

The creep returned to zero after several hours of relaxation at zero pressure, indicating that the creep observed did not represent permanent deformation of plastic.

Full Scale Tests

General Performance

The 66-inch OD \times 58-inch ID Nemo Model 2000 withstood successfully the four successive 24-hour hydrostatic pressure loadings to 450, 900, 1350 and 1800 psi without any appearance of cracks in the acrylic and only minor surface cracking in the polycarbonate plastic bearing surfaces at the polar openings.

Strains

The magnitude of strains observed during the 24-hour pressurization tests is shown in Figure 32; recorded stress values are listed in Table 5. Stress range was predicted by (1) the ZIP-13 finite element computer program and (2) strains generated during the hydrostatic testing of the 15-inch OD \times 13-inch ID Model 34. The fact that the acrylic hull of Model 34 was approximately 10 percent thicker than required by the 1:4.4 scaling factor had to be taken into consideration during comparison of strains measured on the 15-inch and 66-inch diameter hulls.

The highest strains in acrylic plastic were measured on the interior of the hull at the edge of the top polar opening. The strains at the edge of the bottom polar opening were about 10 percent less, reflecting the fact that the bottom aluminum plate is significantly less stiff than the top hatch. The ratios between longitudinal and hoop strains at both locations were in the 3:1-4:1 range.

The interior longitudinal strain at the top polar opening was 100 percent greater than the interior longitudinal strain at the equator, while the interior hoop strain at the top polar opening was 50 percent less than the interior hoop strain at the equator. The exterior longitudinal strain at the top polar opening was only 20 percent greater than the exterior longitudinal strain at the equator, while the exterior hoop strain at the top polar opening was 70 percent less than the exterior hoop strain at the equator. On the aluminum polar inserts the highest strain was measured on the interior surfaces of (1) the bottom plate at location #6 in longitudinal direction and (2) the top plate at location #13 in longitudinal direction (see Fig. 23).

Magnitude of *Creep* at the equatorial surfaces of the hull was approximately the same as that recorded for Model 34. It was for all practical purposes absent during the 24 hour pressurizations to 450 and 900 psi, but it became noticeable (20-25 percent increase over short term strain) during 1350 psi pressurization and was significant (25-30 percent increase) during 1800 psi pressurization, as can be seen in Figure 32a through l. The numerical value of strains on the interior surface at the equator after 24 hours of sustained loading was in the 2500-3000, 5000-6000, 9000-11,000 and 13,000-15,000 micro inches/inch range for, respectively, 450, 900, 1350 and 1800 psi pressurizations. (See Figs. 32i and 32j.)

The numerical values of creep on the interior hull surface at the edges of top and bottom penetrations were higher than at the equator, but in terms of short term strain percentage they were not different from those at the equator. After 24 hours of sustained loading the longitudinal strains at penetrations were in the 4000-4500, 8000-10,000, 15,000-19,000 and 22,000-27,000 micro inches/inch range for, respectively, 450, 900, 1350 and 1800 psi

Table 5. Stresses in 66 Inch OD x 58 Inch ID Nemo Model 2000 Assembly
During the 24 Hour Dive to a Depth of 3000 Feet

Gages		Stress (psi)	
Hull Location	Orientation	Upon reaching 3000 feet	After 24 hours
Inside #1	Hoop	-4,986	
	Longitudinal	-7,914*	
Outside	Hoop	-2,348	
	Longitudinal	-3,819	
Inside #2	Hoop	-5,476	
	Longitudinal	-5,290	
Outside	Hoop	-4,214	
	Longitudinal	-4,186	Stresses cannot be calculated because of creep in acrylic
Inside #3	Hoop	-4,486	
	Longitudinal	-6,714	
Outside	Hoop	-4,900	
	Longitudinal	-3,400	
Inside #4	Hoop	-5,595	
	Longitudinal	-5,438	
Outside	Hoop	-4,086	
	Longitudinal	-4,014	
Inside #5	Hoop	-10,495	-9,396
	Longitudinal	-11,648	-11,319
Outside	Hoop	-5,000	-4,835
	Longitudinal	-5,000	-4,451
Inside #6	Hoop	-13,626	-13,956
	Longitudinal	-17,088**	-18,187**
Outside	Hoop	-6,264	-5,549
	Longitudinal	-5,879	-5,165
Inside #7	Hoop	-13,297	-12,967
	Longitudinal	-10,989	-9,890
Outside	Hoop	-6,429	-6,429
	Longitudinal	-6,429	-6,429

*Highest stress in acrylic hull (during conversion of strains to stresses $E = 400,000$ psi and $\mu = 0.4$ were applied).

**Highest stress in polar aluminum inserts (during conversion of strains to stresses $E = 10,000,000$ psi and $\mu = 0.3$ were applied).

Table 5. (Continued).

<i>Gages</i>		<i>Stress (psi)</i>	
<i>Hull Location</i>	<i>Orientation</i>	<i>Upon reaching 3000 feet</i>	<i>After 24 hours</i>
Inside #8	Hoop	-13,022	-13,187
	Longitudinal	-3,407	-3,956
Outside	Hoop	-3,516	-2,967
	Longitudinal	-55	+110
Inside #9	Hoop	-10,549	-9,341
	Longitudinal	-15,165	-12,802
Outside	Hoop	-4,780	-4,780
	Longitudinal	-5,934	-5,934
Inside #10	Hoop	-10,549	-9,835
	Longitudinal	-10,165	-9,451
Outside	Hoop	-4,670	-4,670
	Longitudinal	-3,901	-3,901
Inside #11	Hoop	-10,165	-9,066
	Longitudinal	-10,549	-10,220
Outside	Hoop	-3,736	-3,736
	Longitudinal	-4,121	-4,121
Inside #12	Hoop	-11,429	-11,429
	Longitudinal	-11,429	-11,429
Outside	Hoop	-3,956	-3,956
	Longitudinal	-3,187	-3,187
Inside #13	Hoop	-11,758	-13,352
	Longitudinal	-12,527	-14,505
Outside	Hoop	-3,956	-6,813
	Longitudinal	-3,187	-6,044
Inside #14	Hoop	-12,692	-14,286
	Longitudinal	-12,308	-14,286
Outside	Hoop	-4,670	-7,527
	Longitudinal	-3,901	-6,758

pressurizations (see Figs. 32b and 32c). Strains in acrylic returned essentially to zero after a 24-hour period of relaxation indicating that the creep in acrylic was not of a permanent nature even after the 24 hour sustained loading to 1800 psi hydrostatic pressure.

Stresses

The *maximum stress* measured on the acrylic hull (see Table 5) at the beginning of 24 hour pressurizations was -2339, -5043, -7914 and -10,962 psi at, respectively, 450, 900, 1350 and 1800 psi pressure loadings. The maximum stress, analyzed as typical for Nemo hulls, ¹³ is located on the interior surface of the hull at the edge of top polar opening and was oriented in the longitudinal direction. The stress on the interior equatorial surface was measured simultaneously as -1804, -3610, -5595 and -7757 psi. The magnitude of stress on the acrylic hull at the conclusion of the 24 hour pressurization periods is not known since there was considerable creep in the plastic which would make any classical stress calculations inaccurate.

The *maximum stress* on the aluminum inserts was measured on the interior of the bottom plate at location No. 6 in the longitudinal direction. The magnitude of the stress at the beginning of 24 hour pressurizations was -4967, -9890, -17,088 and -21,044 psi at, respectively, 450, 900, 1350 and 1800 psi loadings. At the conclusion of the 24-hour pressurization periods the magnitude of the stress had changed to -3198, -9890, -18,187 and -18,846 psi, respectively. After the 24-hour relaxation periods following pressurizations to 450, 900 and 1350 psi, all stresses in aluminum returned essentially to zero, as listed in Table 6. A different case presented itself at the conclusion of the relaxation period following the 24-hour pressurization to 1800 psi. Here the stresses at interior location Nos. 6, 13 and 14 on aluminum inserts not only failed to return to zero (see Table 6) but showed residual positive stresses of significant magnitude, and the reasons for their presence are not known. A more detailed listing of stresses is presented in Appendix C.

The *comparison* of stresses calculated on the basis of experimental data and the ZIP-13 finite element computer program show good agreement for all locations on the acrylic hull. For locations on aluminum inserts the agreement is not as good. It appears that for the locations on the exterior of aluminum inserts the calculated stresses are generally lower than measured values, whereas for locations on the interior of the inserts the calculated values are generally higher. However, since the highest stresses measured on aluminum inserts were on the interior surface, the calculated values tend to be conservative in nature and, thus, useful in the design of pressurized Nemo Hulls. A complete listing of computer generated strains and stresses for the Model 2000 Nemo Hull assembly is presented in Appendix D.

Table 6. Residual Strains in Aluminum Plates and Hatches
of the 66 Inch OD x 58 Inch ID Nemo Model 2000
after Repeated 24 Hour Long Pressurizations

Gage Locations							
Test		No. 6 Inside		No. 13 Inside		No. 14 Inside	
		Hoop	Longitudinal	Hoop	Longitudinal	Hoop	Longitudinal
450 psi	A	-240	-380	-190	-200	-250	-140
	B	-170	-240	-120	-140	-250	-140
	C	+120	+150	+100	+110	+10	+80
	D	+160	+180	+130	+210	+80	+60
900 psi	A	-500	-750	-450	-500	-500	-500
	B	-500	-750	-450	-500	-500	-500
	C	0	+100	+50	+0	+50	0
	D	+50	+150	+100	+0	+100	50
1350 psi	A	-850	-1300	-800	-900	-900	-850
	B	-850	-1400	-900	-1050	-1000	-1000
	C	0	0	+0	-100	-100	-150
	D	0	0	+0	-150	-200	-200
1800 psi	A	-1050	-1400	-1000	-1150	-1150	-1100
	B	-1050	-1400	-850	-1050	-1050	-1000
	C	+50	+300*	+200*	+100*	+50*	+500*
	D	-50	+2350*	+1450*	+1350*	+1350*	+1250*

A Immediately after pressurization

B After 24 hours of sustained pressurization

C Immediately after pressure release

D After 24 hours of relaxation

* Questionable values, probably generated by malfunctioning bulkhead penetrators for instrumentation in Model 2000 Nemo Hull, or pressure vessel end closure.

TEST DATA DISCUSSION

Determination of Safe Operational Depth

In order for the chosen operational depth to be safe, many operational as well as hull performance parameters, must be considered and carefully calculated.

Hull Performance Parameters

The *short term critical pressure* at which catastrophic implosion of the hull occurs in an uncontrolled dive is the best known and easiest to obtain performance parameter of an acrylic hull. The short term critical pressure represents the ultimate depth beyond which a submersible cannot descend at any time. For the Model 2000 Nemo Hull the short term critical pressure has been experimentally established at approximately 10,000 feet. The actual short term implosion test was performed on the 15-inch Model 34, which imploded at 4700 psi external hydrostatic pressure. Since the scale model is about ten percent thicker than required, the extrapolated short term implosion pressure for the full scale Model 2000 Nemo Hull is around 4000 psi if the same pressurization procedure is used as for the scale model. However, since the pressurization schedule for Model 34 did not correspond to the typical 100 psi/minute short term pressurization rate for acrylic hulls² (recording of strain data at 4500 and 4700 psi pressure levels delayed the pressurization by 5 minutes), the extrapolated short term collapse pressure for the Model 2000 Nemo Hull must be increased from 4000 psi to at least 4500. (Reference 6 indicates that the effect of delay in pressurization at pressures above 4500 psi is to reduce the short term implosion pressure of acrylic hull by about 100 psi for every minute of delay.) The 10,000-foot short term implosion depth gives the Model 2000 Nemo Hull the ability to bounce dive once under extreme emergency conditions probably to at least 8000 feet.

The *long term critical pressure of acrylic hulls* has been previously established⁶ as a function of time and temperature. Because 100 hours is considered the maximum length of time that the crew of a submersible could survive under entrapment without new air support supplies, this time span will be used to establish a long term critical pressure. This pressure can be readily determined from a plot of experimental data generated by implosions of 15-inch OD x 13-inch ID Models 22, 23, 24, 25 and 34 as illustrated in Figure 33.⁶ From the plot one can see that the implosion pressure of a scale model Nemo Hull under 2700 psi sustained loading at 70-75°F at ambient temperatures occurs after 100 hours. After application the 0.86 correction factor (based on plastic instability, takes into account the ten percent thicker hull of scale models), the projected 100 hour long term critical pressure of the Model 2000 Nemo Hull is 2320 psi in the 70-75°F ambient temperature range. In terms of depth it can then be stated that the Model 2000 Nemo Hull must be trapped for at least 100 hours at a depth of about 5000 feet before catastrophic failure occurs.

The *cyclic fatigue life* of acrylic hulls has been the subject of several studies since, as a rule, it is the determining factor in setting the safe operational depth of an acrylic hull. Since the cyclic fatigue life is not only a function of maximum pressure in the pressure cycle but also of duration and temperature, they all must be taken into consideration. Study of typical dive profiles for submersibles has established the fact that a submersible does not

stay at maximum operational depth longer than 4 hours. The rest of the typical dive is taken up by launching, descent, ascent, docking and retrieval. The temperature can vary widely during a dive but at operational depths it is usually below 50 degrees. Since pressure cycling at 70-75°F is not only more conservative, but also more economical, it was used to establish the cyclic fatigue life of the Model 2000 Nemo Hull.

The testing of 15-inch Models 35, 36 and 37 has conclusively shown that crazing appears in the acrylic hull at the polar openings without the polycarbonate gasket only after 1000 pressure cycles of 8-hour duration (4 hours loading followed by 4-hours relaxation) to 1500 psi. No crazing was observed in the polar opening of the acrylic hull protected by the polycarbonate gasket. Judging by these results the minimum crack-free fatigue life of the 15-inch OD x 13-inch ID Models is 1000 cycles to a maximum operational depth of 3350 feet. Based on the scale model data, the 60-inch OD x 58-inch ID Model 2000 Nemo Hull can perform 1000 dives to 3000 feet without initiation of cracks in the acrylic hull.

Operational Performance Parameters

In view of the fact that preservation of the crew is the major consideration in the design of pressure hulls it is considered mandatory that the short-term and long-term critical pressures be beyond the depth to which the submersible may be accidentally submerged. Furthermore, it is considered reasonable and customary that the implosion depth for a long term (no more than 100 hours) disabled submersible be at least 50 percent greater than the maximum operational depth (safety factor of 1.5). For a short term loss of control, the implosion depth should be at least 100 percent greater than the maximum operational depths (safety factor of 2).

In addition to preserving the crew there are also the economics of the hull life to be considered. If the fatigue life was set at 100 dives it would prove economically unsound since it would allow the submersibles to operate only for a period of time less than two years, although at greater depths. Similarly, if the fatigue life was stipulated as 10,000 cycles it would give the submersible unlimited life but at the cost of very shallow operational depth, which would significantly lower its operational usefulness. It is the author's opinion that a specified crack-free fatigue life of 1000 cycles represents a sound economical compromise between the operational depth and life of the submersible. For the full scale Model 2000 Nemo Hull the crack-free fatigue life has been experimentally established as 1000 dives to a maximum operational depth of 3000 feet. Since the 3000-foot fatigue life depth is based on 4-hour long simulated dives, there is no need to apply any pressure cycle duration discounting factor to the experimentally established fatigue life depth of 3000 feet.

Based on the factors discussed above, the maximum operational depths should not exceed 4000 feet (8000 feet / 2) for short term disablement criterion, 3330 feet (5000 feet / 1.5) for long term disablement criterion, and 3000 feet (3000 feet / 1) for the fatigue life criterion. Since it is the least permissible operational depth, based on any of the above three criteria, that determines the actual depth rating of the hull, fatigue becomes the determining factor for establishing the operation depth rating of the Model 2000 Nemo Hull. As a result 3000 feet is considered as the maximum operational depth rating for the Model 2000 Nemo Hull.

FINDINGS

1. The 66-inch OD X 58-inch ID spherical capsule assembly, Model 2000 Nemo Hull, fabricated from commercial grade (Plexiglas G or equivalent) acrylic plastic and equipped with polycarbonate gaskets between aluminum hatches and the acrylic plastic will withstand a minimum of 1000 dives (4 hours at maximum depth, followed by 4 hours at the surface) from 0 to 3000 feet without initiation of cracks in the acrylic hull.

2. At the safe maximum operational depth of 3000 feet the maximum compressive stresses in aluminum hatches and acrylic plastic hull are only equal to 49 and 52 percent of, respectively, aluminum and acrylic plastic yield strengths.

3. Model 2000 Nemo capsule assembly will withstand accidental disablement at a depth of 5000 feet for at least 100 hours before catastrophic failure occurs. At greater depths the grace period prior to catastrophic failure is significantly shorter, as shown in Figure 33.

4. Model 2000 Nemo capsule assembly will withstand a temporary loss of control to a depth of 8000 feet for about 10 minutes before catastrophic failure occurs.

5. Model 2000 Nemo capsule assembly is an active acoustic stress wave emitter whose rate of acoustic emissions increases significantly just prior to short term implosion.

6. Permanent deformation of aluminum inserts (top hatch and bottom plate) takes place in areas of high stress concentrations when Model 2000 Nemo Hull is subjected to dives of 4000 feet.

7. Long term submersion of 24-hour duration, to 4000-foot depth, does not generate any cracks in the acrylic plastic hull or polycarbonate gaskets at the polar openings and the strains in acrylic plastic after a 24 hour relaxation period at atmospheric pressure return essentially to zero.

CONCLUSION

Spherical acrylic plastic hulls of Nemo Hull design with a $t/r_0 = 0.123$ thickness can be man-rated for a minimum of 1000 operational dives to a maximum operational depth of 3000 feet.

OPERATIONAL RECOMMENDATIONS

1. The Model 2000 Nemo capsule assembly should, during its operational life, never be subjected to depths greater than 3300 feet. The proof test should preferably utilize a test depth of 3300 feet. Under no conditions should the magnitude of proof-test depth exceed 3600 feet unless stronger polar inserts are substituted for the standard Model 2000 Nemo Hull aluminum inserts.

2. The cyclic crack free fatigue life of the Model 2000 Nemo Hull should be *conservatively* considered to be in excess of 12,000,000-foot-hours (1000 cycles \times 3000 foot depth \times 4 hours duty). At the conclusion of each dive, the recorded foot-hours should be subtracted from the initial 12,000,000-foot-hour fatigue life. When the sum of foot hour sub-totals generated by dives equals 12,000,000-foot-hours, inserts and gaskets should be removed from the capsule and the entire hull subjected to a detailed visual examination.

If no cracks are observed at the penetrations in the hull, the capsule should be strain gaged, reassembled, proof-tested to 3300 feet and resulting strains compared to those generated during the first proof test conducted immediately after fabrication of the capsule. Significant differences in strain behavior will be considered important evidence of hull deterioration and should result in significantly reduced depth rating. Cracks in bonded joints originating at inclusions will be repaired if their length exceeds 0.5 inches. Cracked polycarbonate gaskets should be replaced with new gaskets.

If no significant difference in strain behavior is observed, the capsule assembly will be returned to service with a 3000 foot operational depth rating and an additional 12,000,000-foot-hour fatigue life. When the 12,000,000-foot-hour life is used up the capsule assembly will be subjected to the same inspection and proof-testing procedures conducted at conclusion of the first 12,000,000-foot-hour period. If the results of the new inspection and proof-testing are satisfactory, the capsule will again return to service with a 3,000-foot depth rating and additional 12,000,000-foot-hour life.

The recertification process will be repeated until either cracks are observed in the bearing surfaces of acrylic hull during one of the inspections or the strains change significantly. If cracks are observed they will either be repaired by routing and recasting with resin prior to retesting of the hull, or they will be left in place and the hull's depth rating will be reduced to 600 feet.

Subsequently, the hull will be inspected without disassembly for signs of crack propagation every 100 dives. When the depth of any crack exceeds 1 inch, as pictured in Figure 34, the capsule will be taken out of service immediately and the cracks repaired either by enlarging the polar opening or by recasting cracked areas. If not repaired, such a hull can be recertified for service to 120 feet. If, during periodic inspections conducted every 100 dives, the depth of the crack at the penetration is found to exceed 2 inches the acrylic hull will either be repaired or declared unfit for manned operation at any depth.

3. Attempts should be made to ensure that operators be seated inside the Nemo Hull as close as possible to the center of the sphere in order to minimize optical distortion.¹⁵ Camera mounting should be located at the center of the hull if wide angle panning with the camera is to be performed during the mission.

Objects in hydrospace will appear smaller and closer to the hull than they are in reality.¹⁵ Some experience on the part of the crew will be required to judge the distances correctly between the hull and the objects in hydrospace.

4. Many functions of the equipment mounted externally to the submersible can be controlled by modulated light beams projected from the interior of the hull by the crew.¹⁶ This type of arrangement will eliminate many electrical penetrators in the bottom plate and make the control of externally stored scientific equipment an operationally easy matter.



Figure 1. Acrylic plastic hull with the typical Nemo polar penetrations, metallic hatches, and spherical pentagon modular construction.

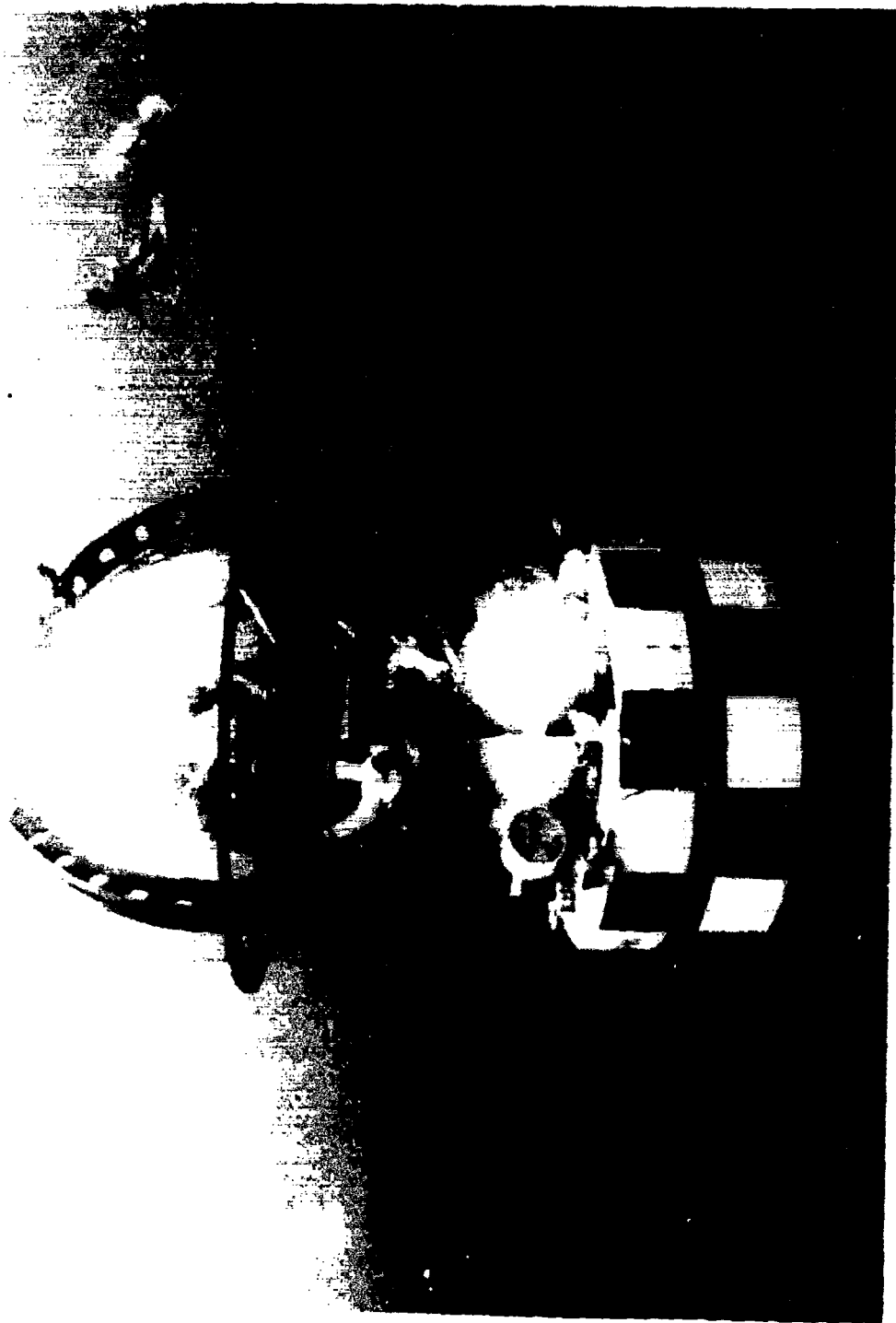


Figure 2. Nemo submersible, approved in 1970 by the U. S. Navy for manned operations to 600 feet.

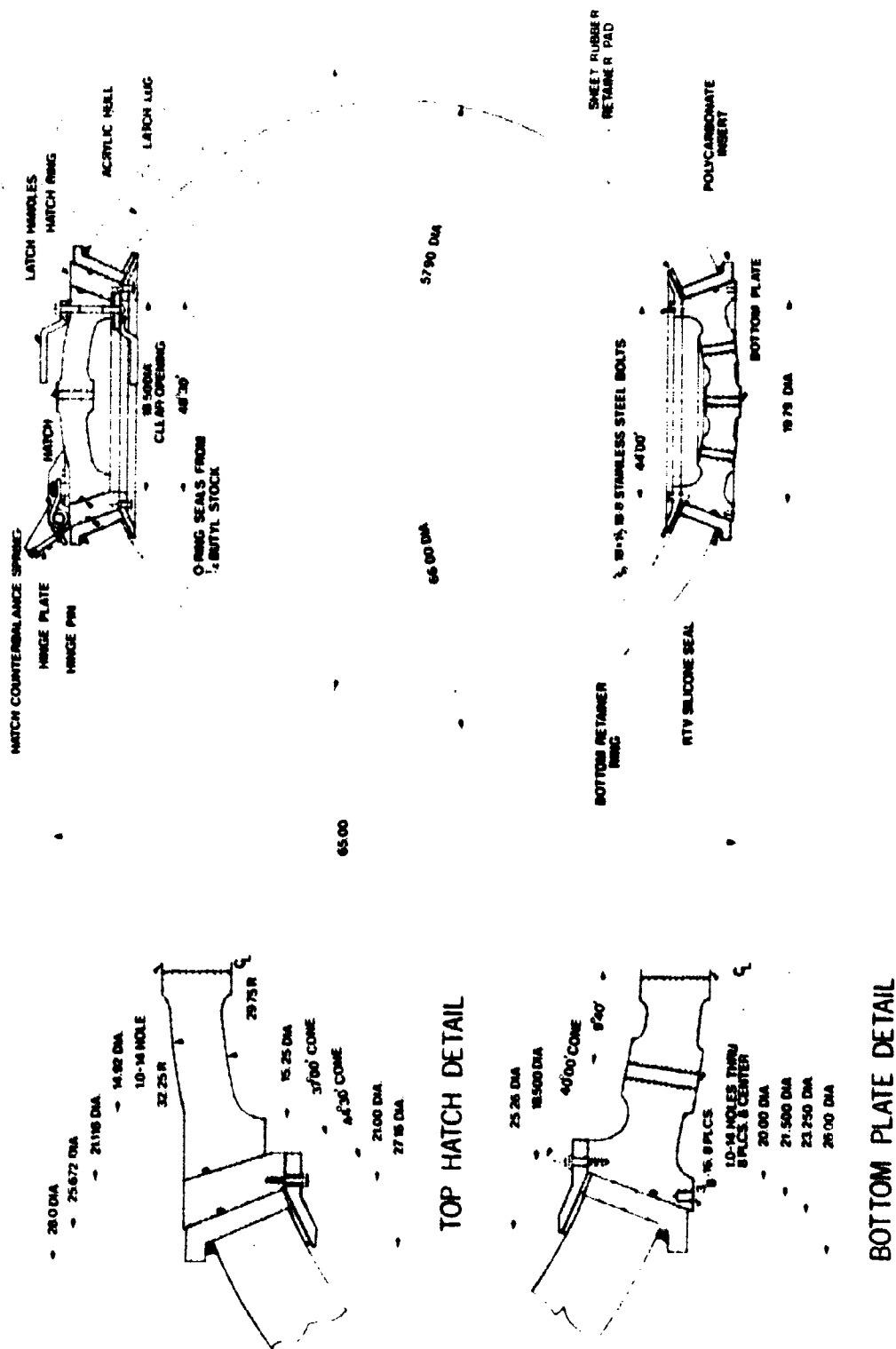


Figure 3. Schematic of the Model 2000 Nemo Hull.

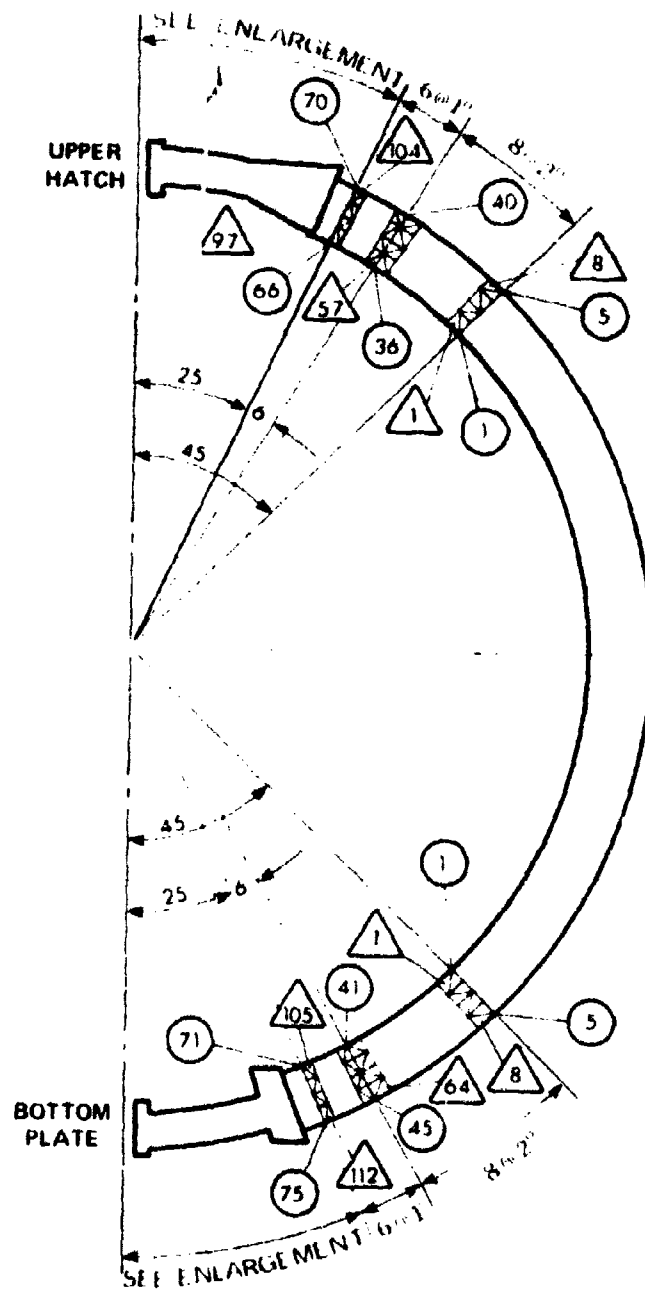


Figure 4 Idealized shape of the Model 2000 Nemo Hull assembly used in the ZP 13 finite element stress analysis.

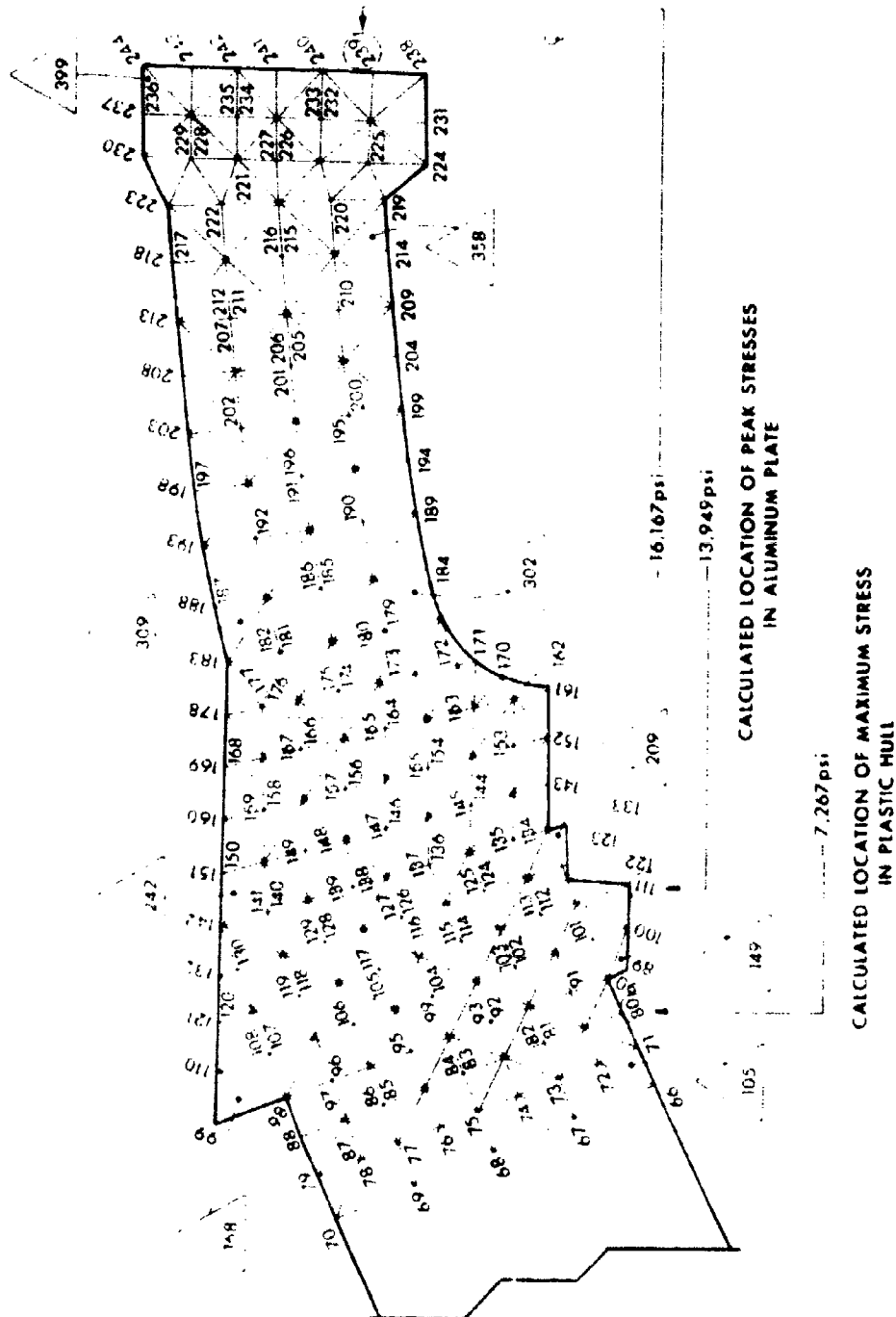


Figure 5. Idealized shape of the top hatch used in the ZP 13 finite element stress analysis of the Model 2000 Nemo Hull under simulated 900 psi external hydrostatic pressure.

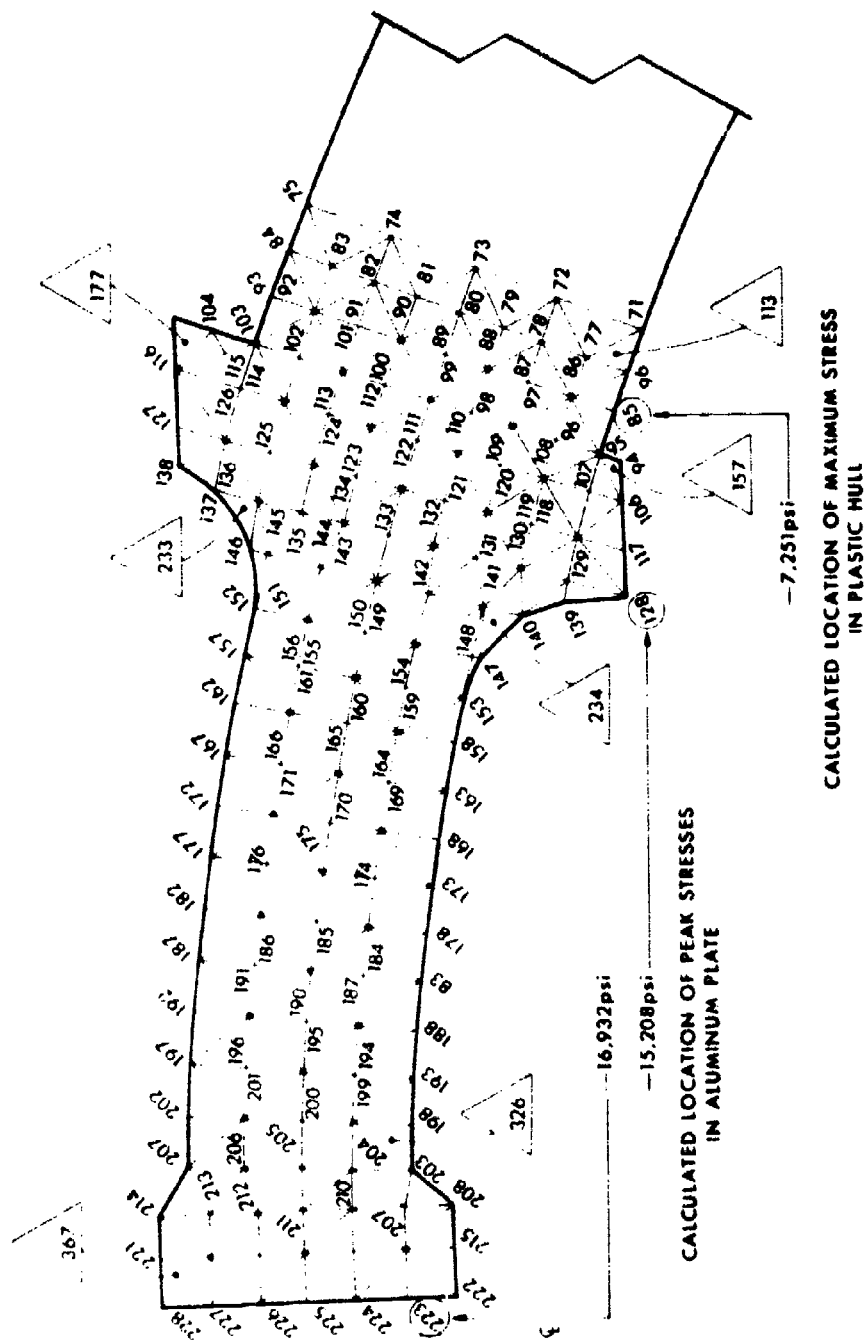


Figure 6. Idealized shape of the bottom plate used in the ZP 13 finite element stress analysis of the Model 2000 Nemo Hull under simulated 900 psi external hydrostatic pressure.

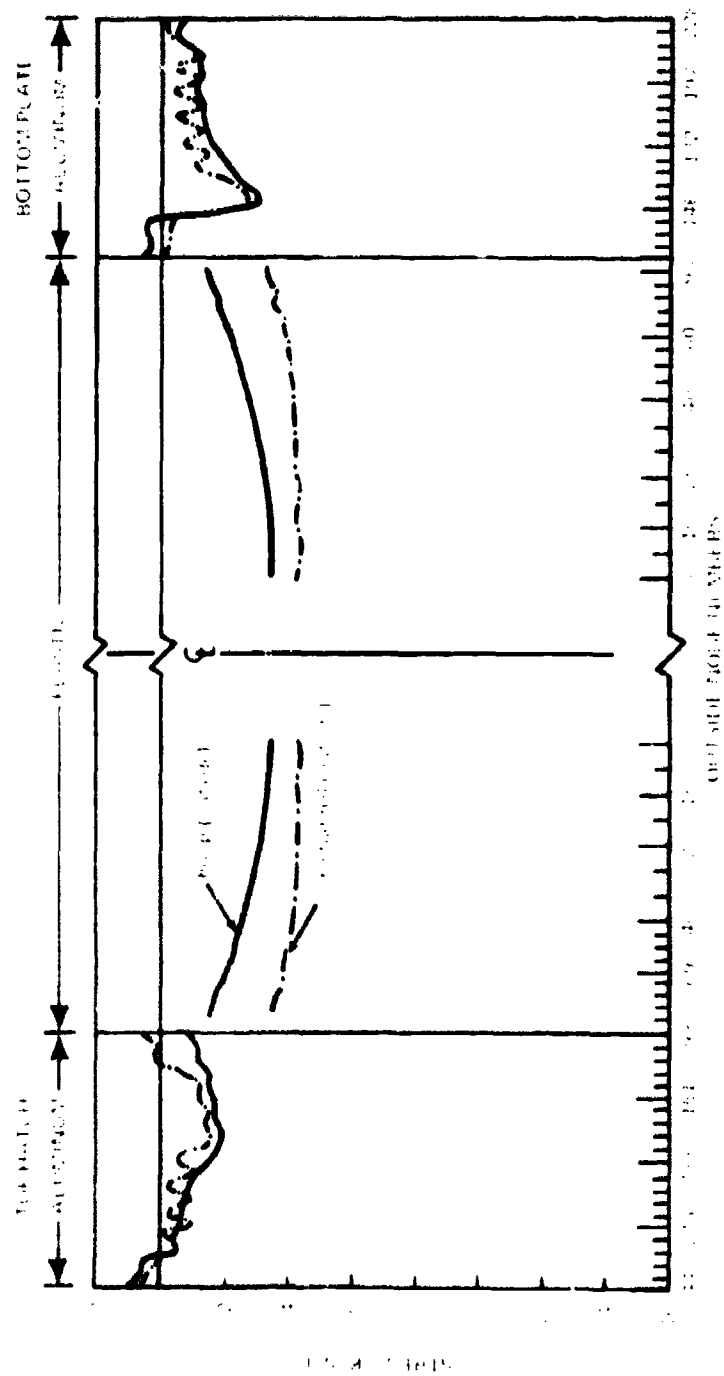


Figure 7. Calculated stress distribution in the Model 2000 Nemo Hull assembly under simulated 900 psi external hydrostatic pressure, outside surface.

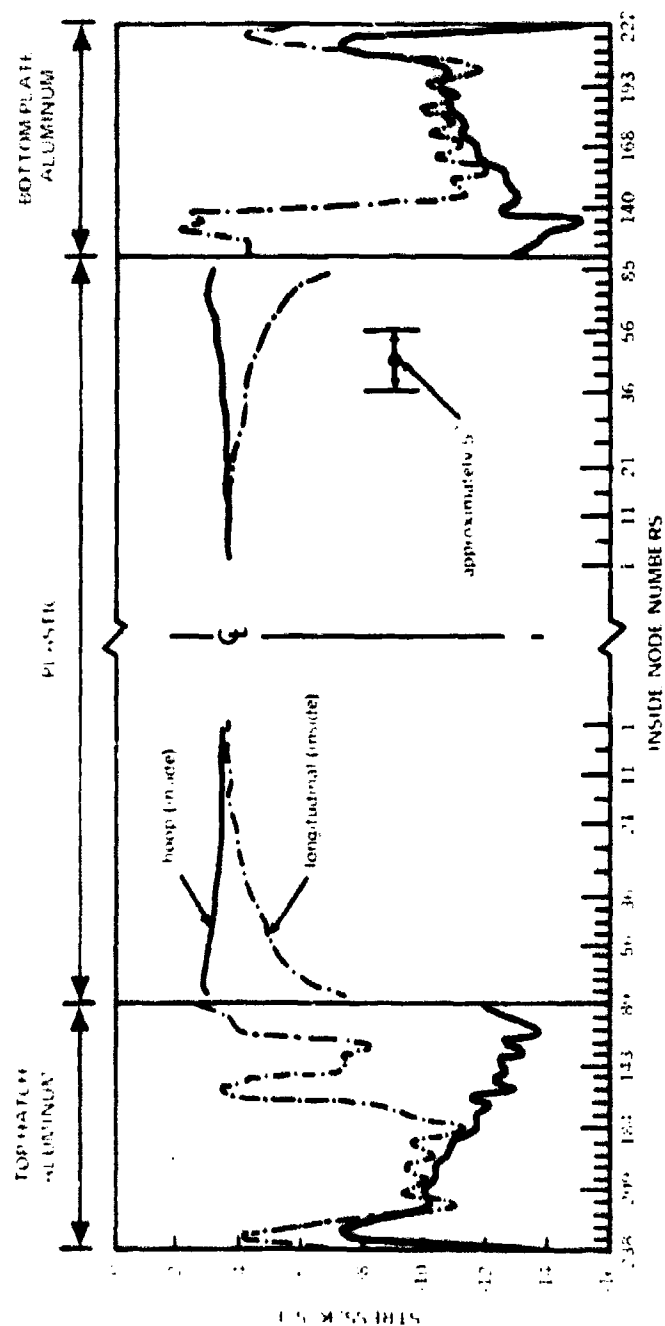


Figure 8. Calculated stress distribution in the Model 2060 Nemo Hull assembly under simulated 900 psi external hydrostatic pressure: inside surface.



Figure 9. Assembled Model 2000 Nemo Hull undergoing final polishing.

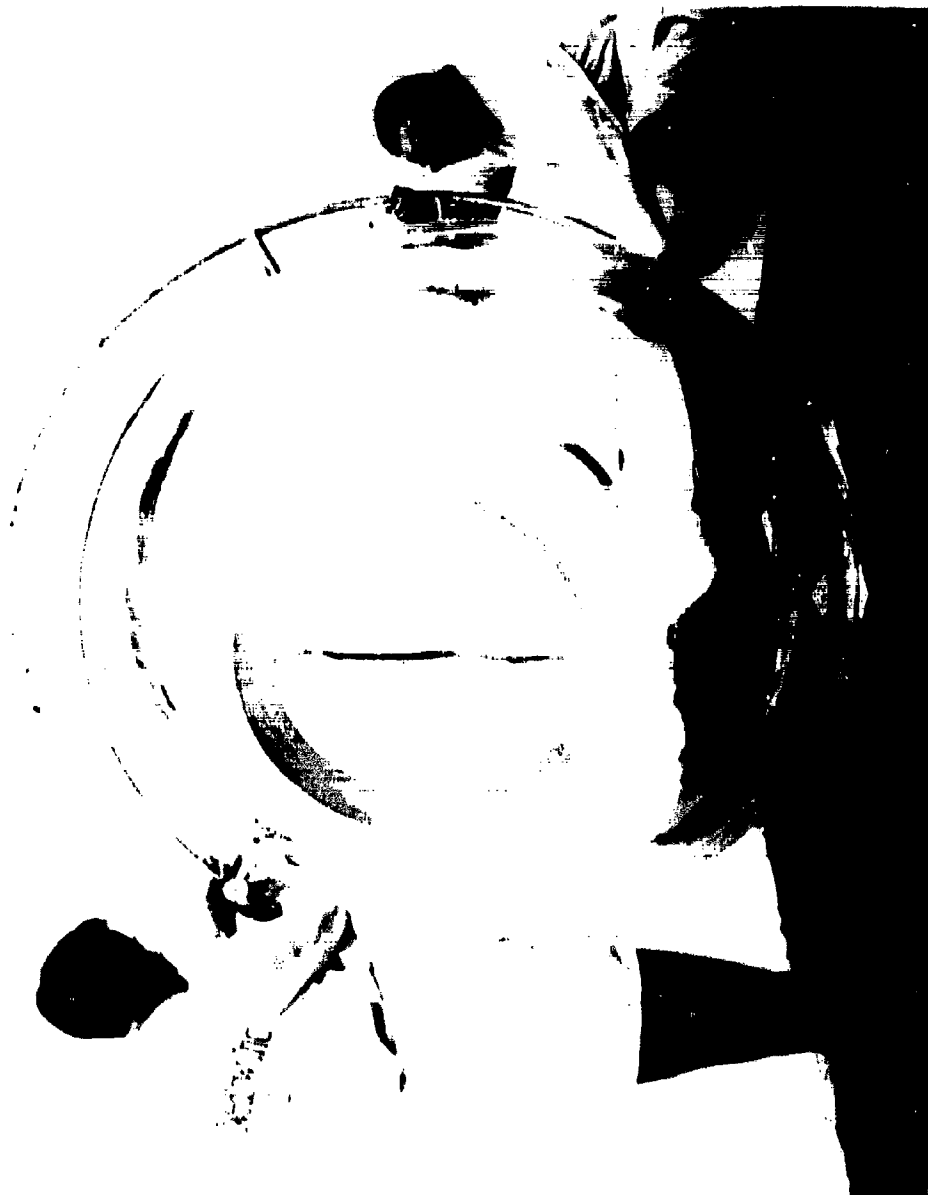


Figure 10 Inspection of Model 2000 Nemo Hull for out-of-roundness at Swedlow Inc.

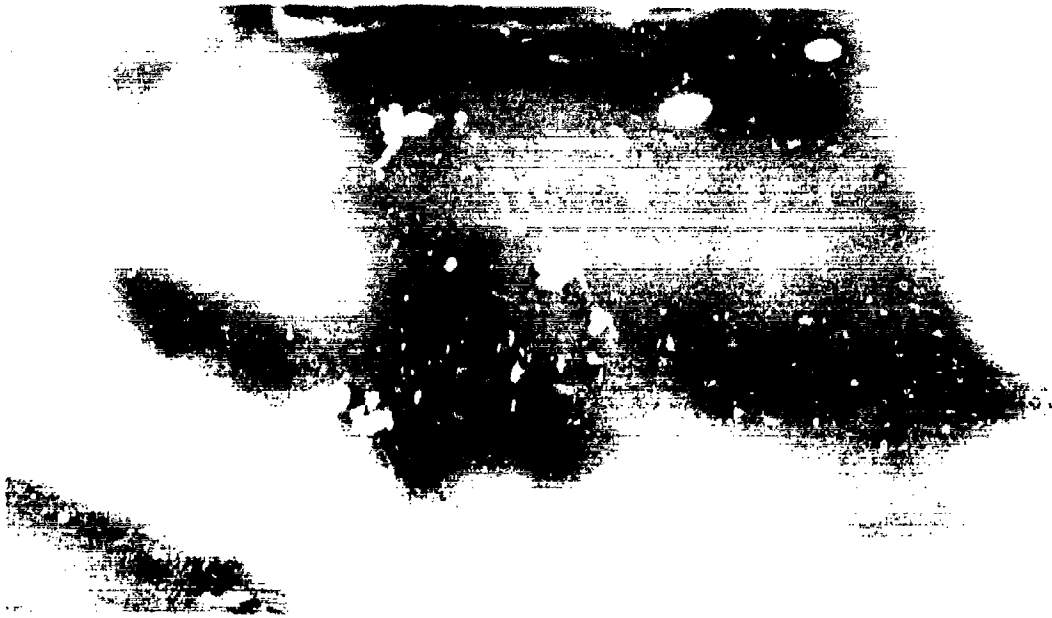
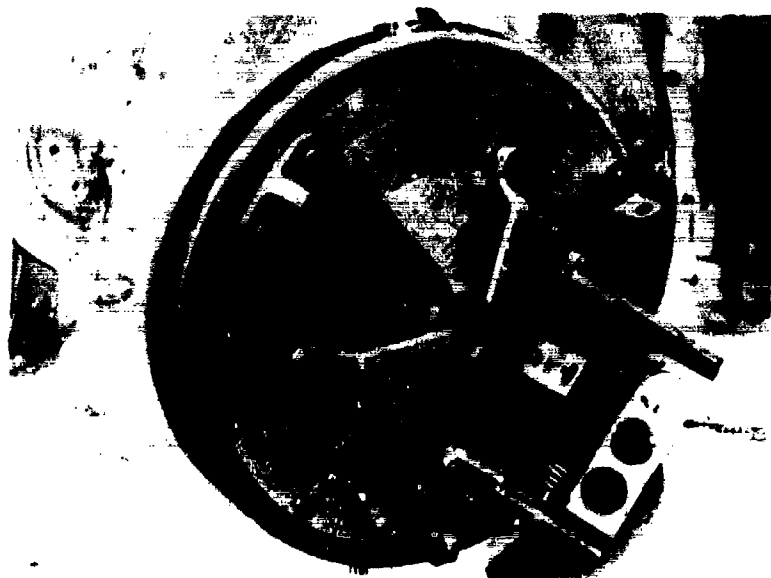
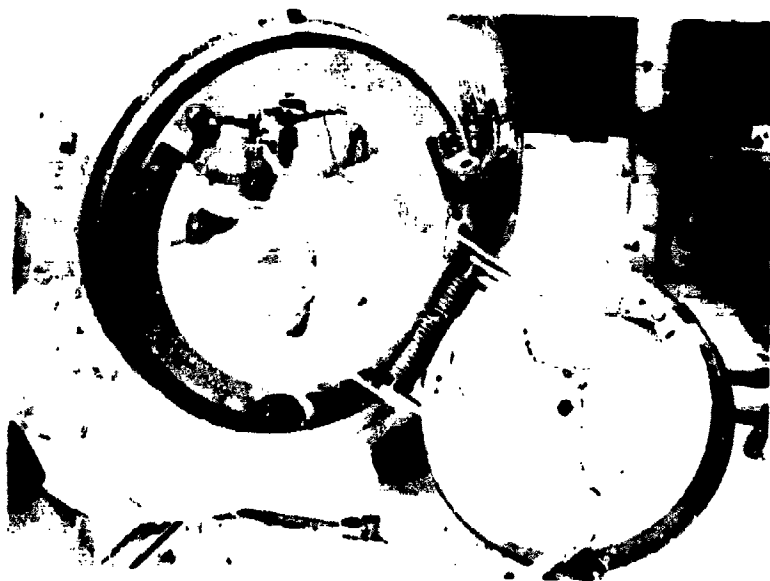


Figure 11. Typical bonded joint between spherical pentagons.



(a) outside view



(b) inside view

Figure 12. Aluminum hatch for Model 2000 Nemo Hull.



(a) outside view



(b) inside view

Figure 13. Aluminum bottom plate for Model 2000 Nemo Hull.

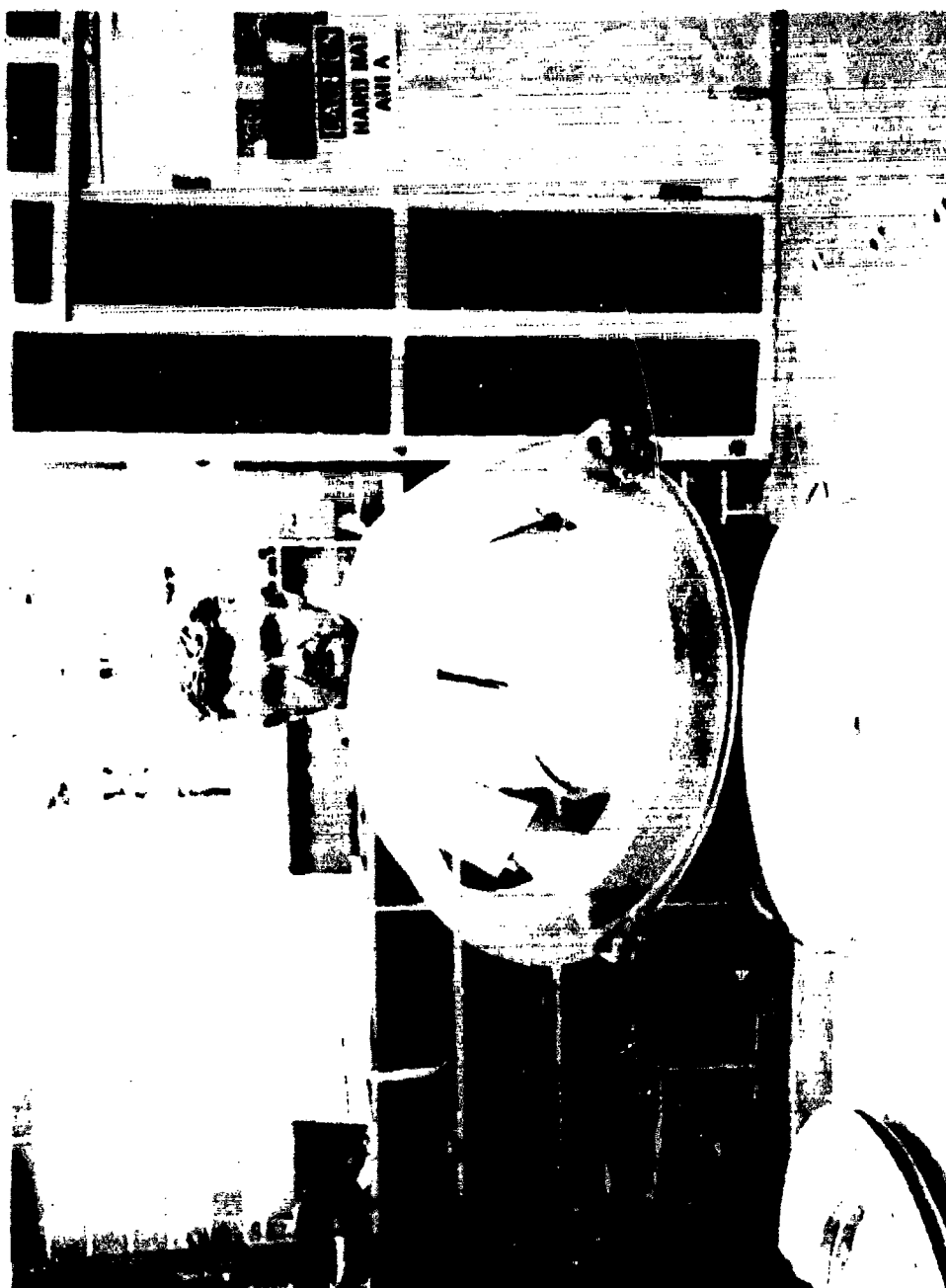
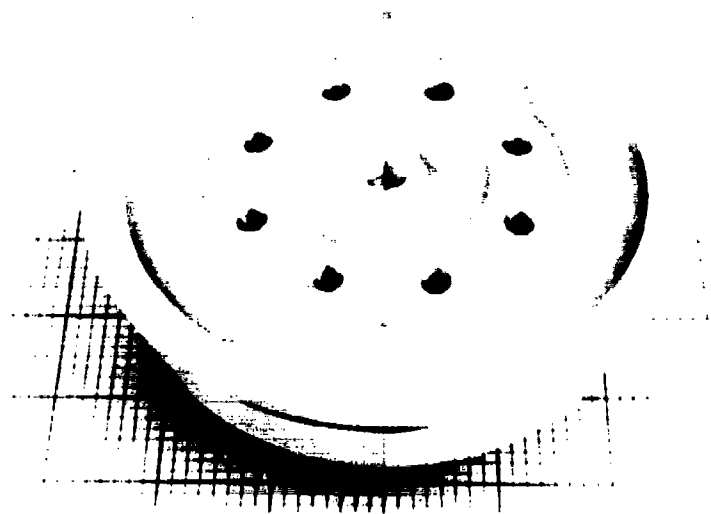


Figure 14. Bearing gasket for polar openings in the hull fabricated from polycarbonate plastic plates.



Figure 15. 15 inch OD X 13 inch ID Model 34 serving as scale model of the Model 2000 Nemo Hull assembly.



(a) outside view

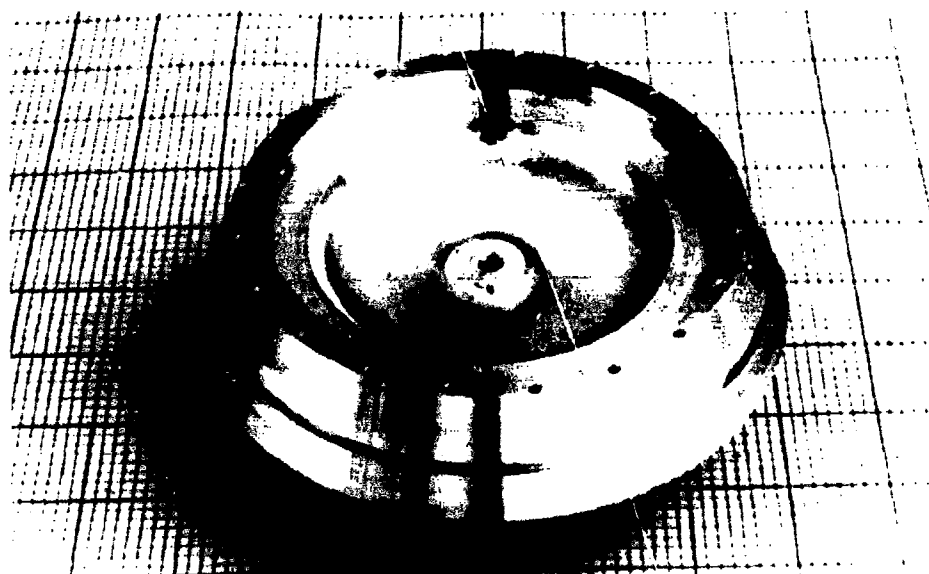


(b) inside view

Figure 16. Aluminum bottom plate for 15 inch OD \times 13 inch ID Model 34 serving as scale model of Model 2000 Nemo Hull assembly.

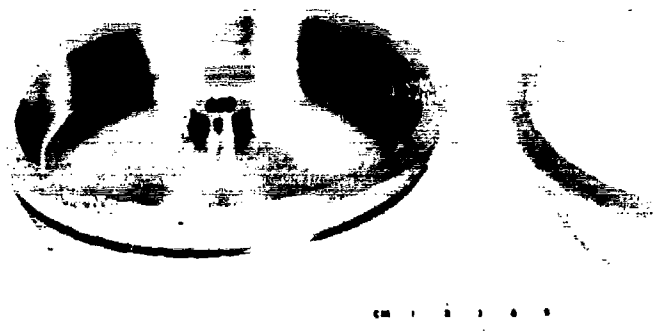


(a) outside view of hatch and retaining ring



(b) inside view

Figure 17. Aluminum hatch for 15 inch OD \times 13 inch ID Model 34 serving as scale model of Model 2000 Nemo Hull assembly.

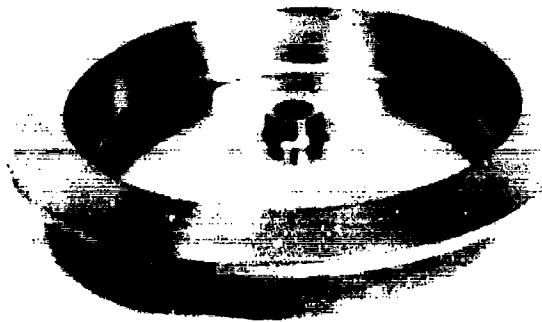


(a) exterior view of hatch designed for service with polycarbonate gasket

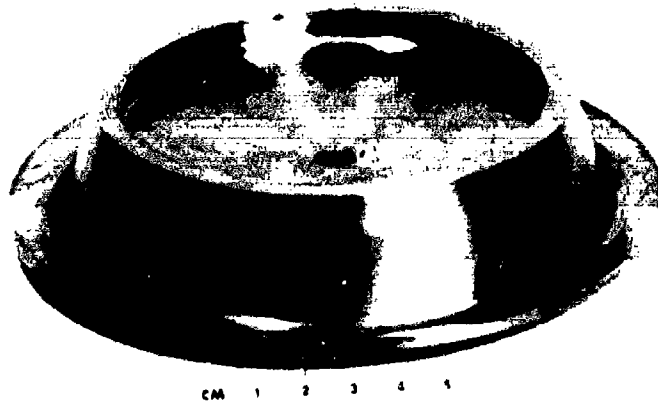


(b) interior view of hatch designed for service with polycarbonate gasket

Figure 18. Titanium hatch for 15 inch OD \times 13 inch ID Models 35, 36 and 37.



(c) exterior view of hatch designed for service without a polycarbonate gasket



(d) interior view of hatch designed for service without a polycarbonate gasket

Figure 18. (Continued).

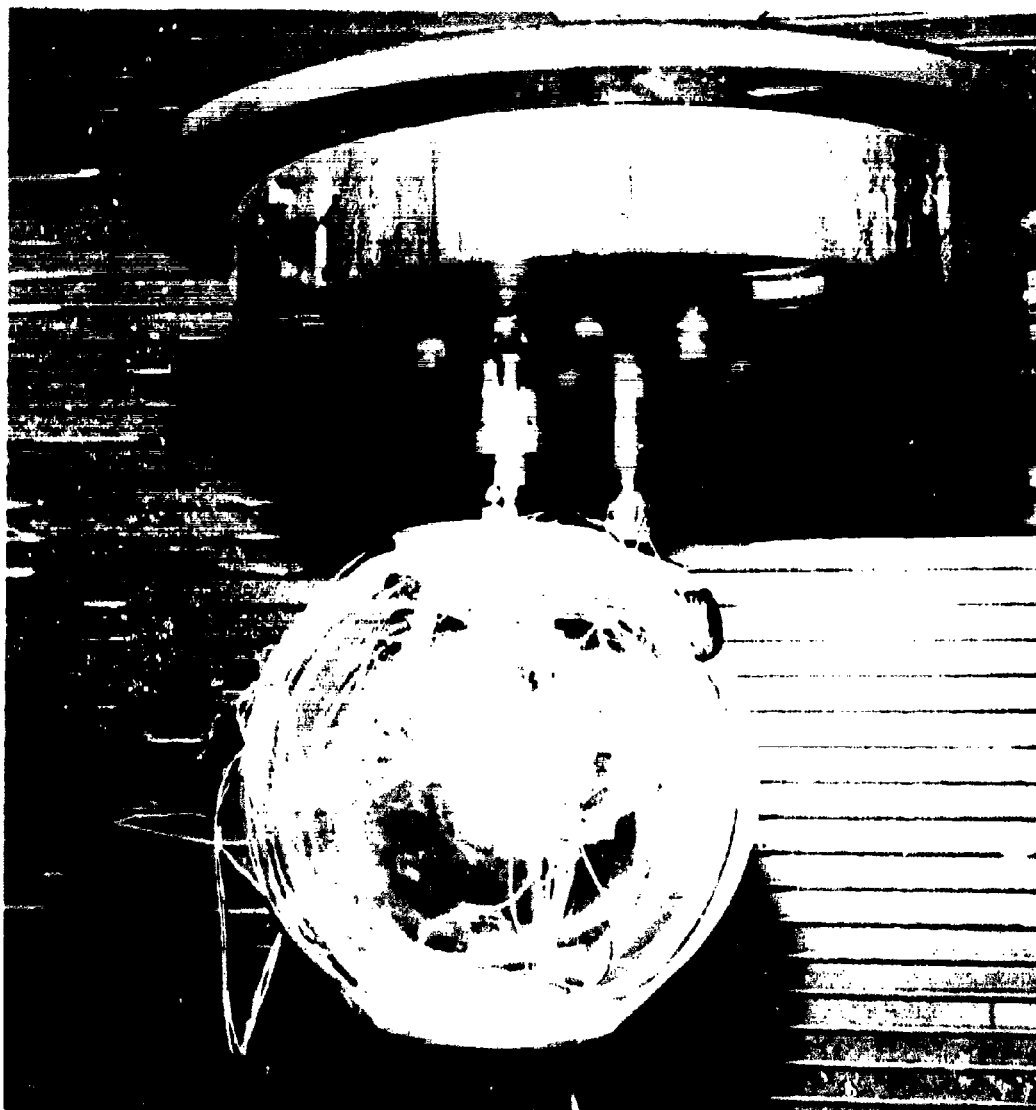
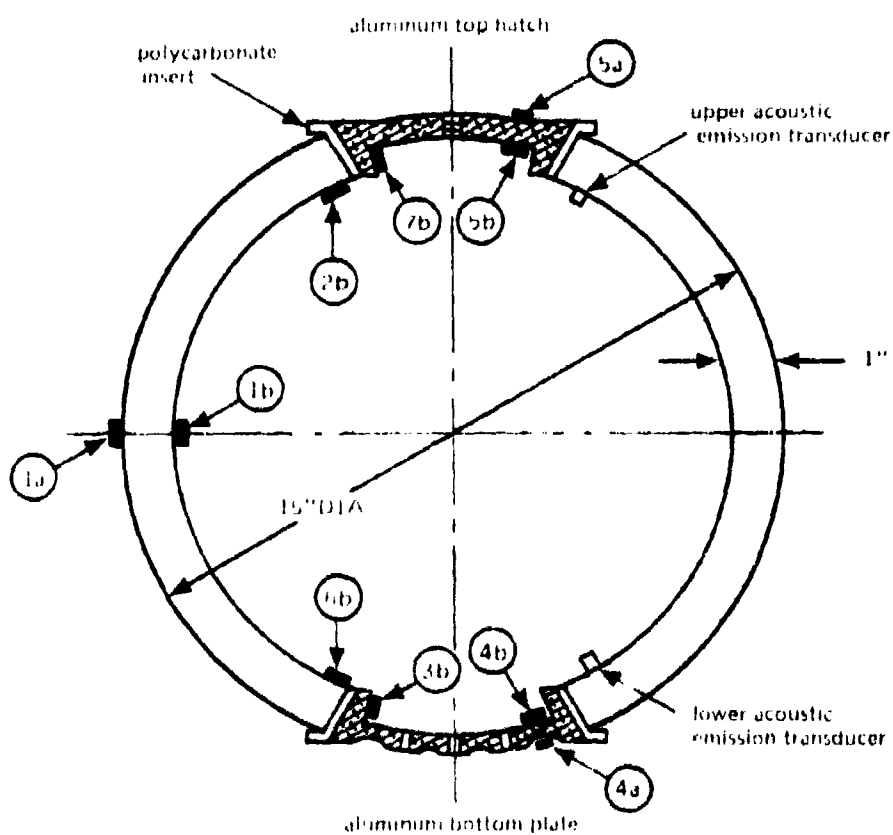


Figure 19. Test arrangement for hydrostatic testing of 15 inch OD \times 13 inch ID Model 34 serving as scale model of Model 2000 Nemo Hull.

2b = 0.500 inches from edge of hatch
 6b = 0.700 inches from edge of bottom plate



Note: Each number instrumented with 2 gage 90° rosettes

Figure 20. Location of strain gages on the 15 inch OD x 13 inch ID Model 34, serving as scale model of Model 2000 Nemo Hull.

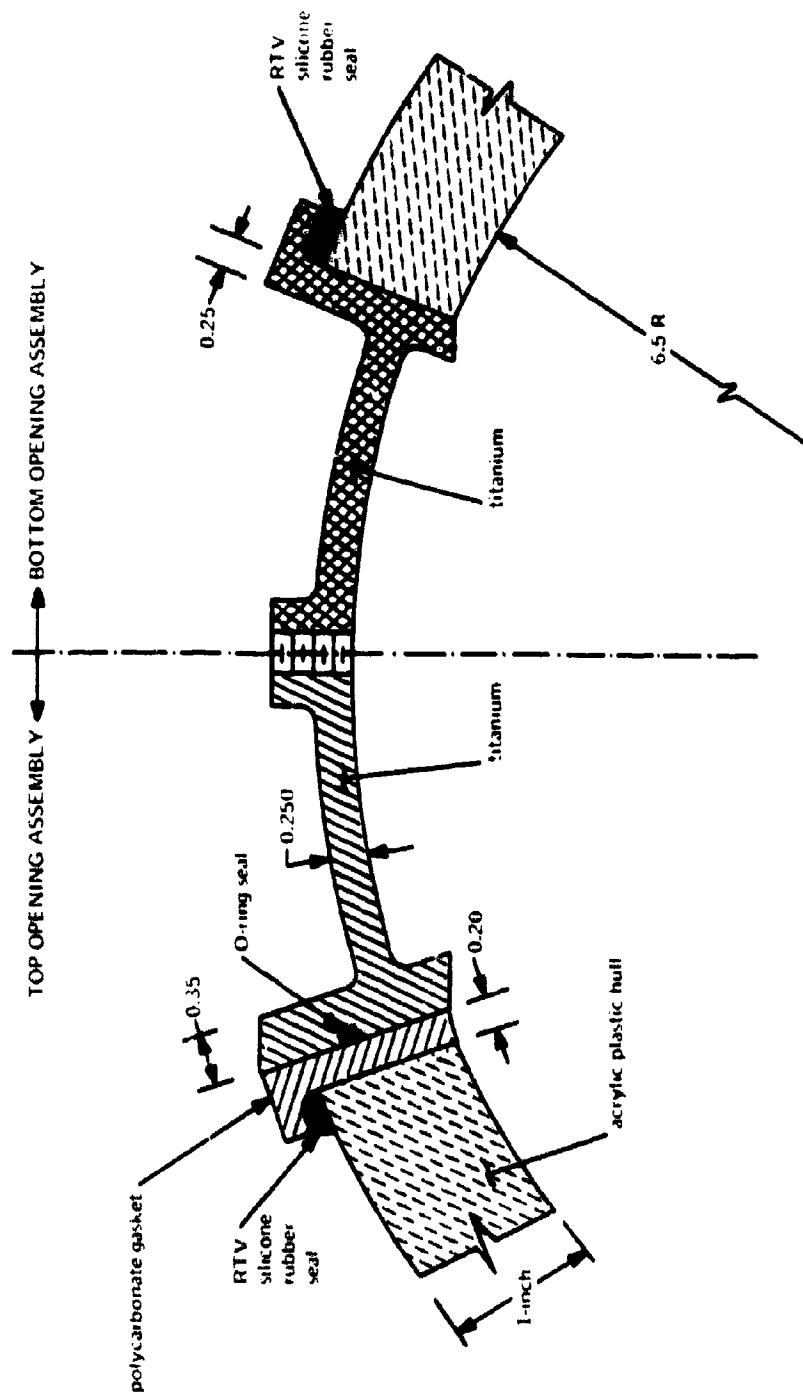
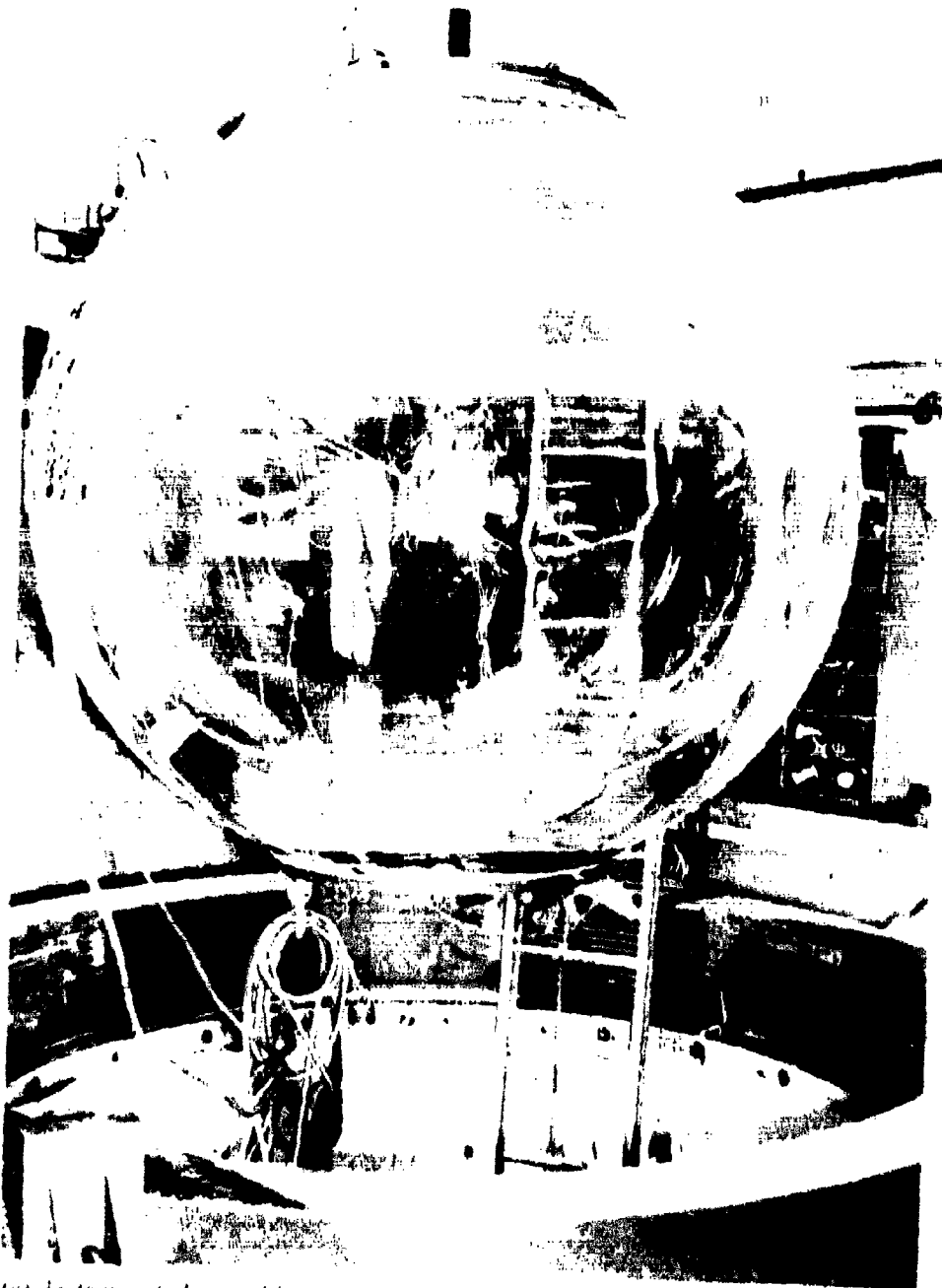
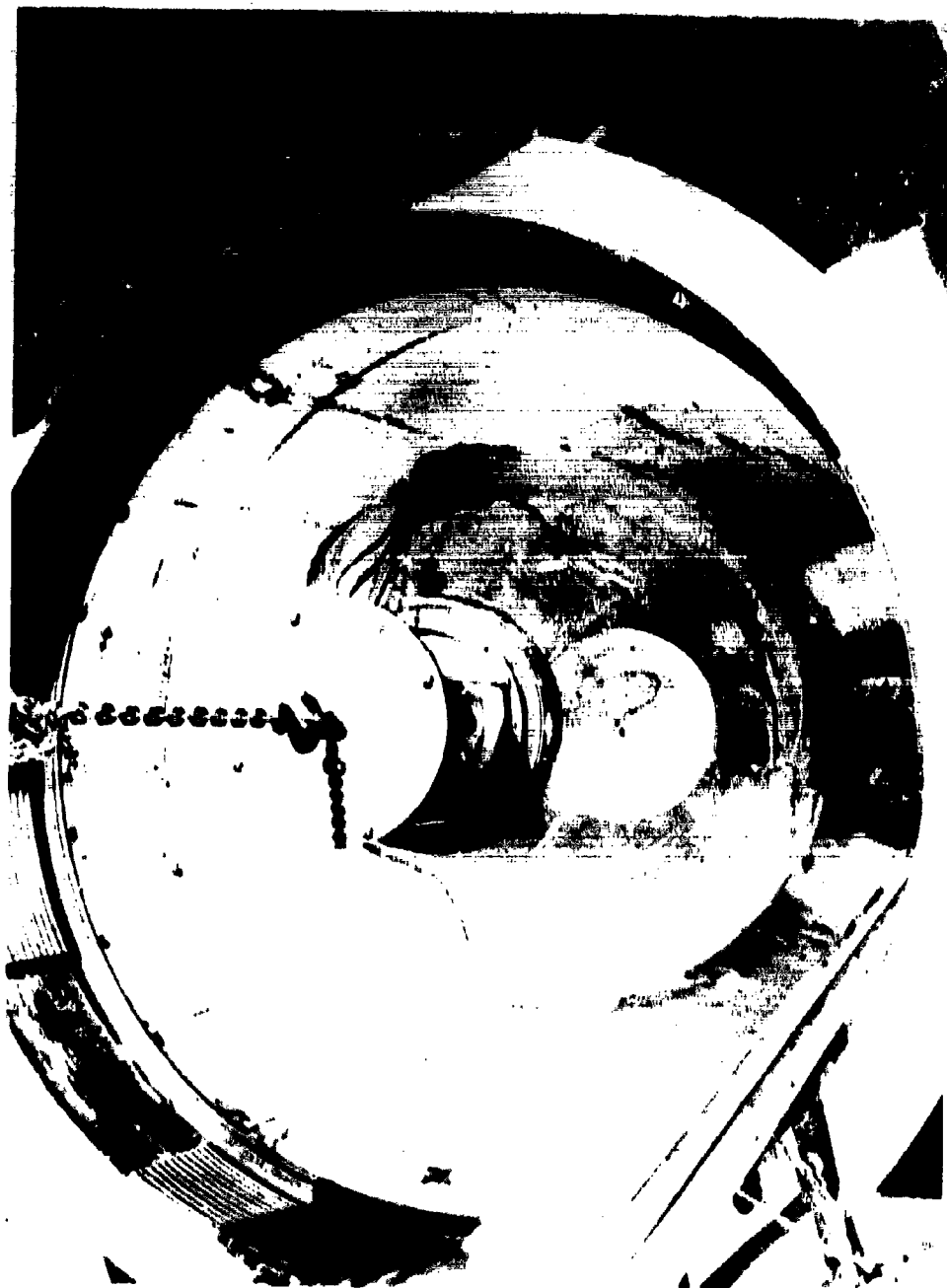


Figure 21. Typical hatches used in the 15 inch OD \times 13 inch ID Models 35, 36 and 37 subjected to pressure cycling.



(a) Instrumented assembly ready for placement in vessel

Figure 22. Testing of full scale Model 2000 Nemo Hull assembly in the 90 inch diameter pressure vessel at SWRI.



(b) Model 2000 Nemo Hull assembly in vessel

Figure 22. (Continued).

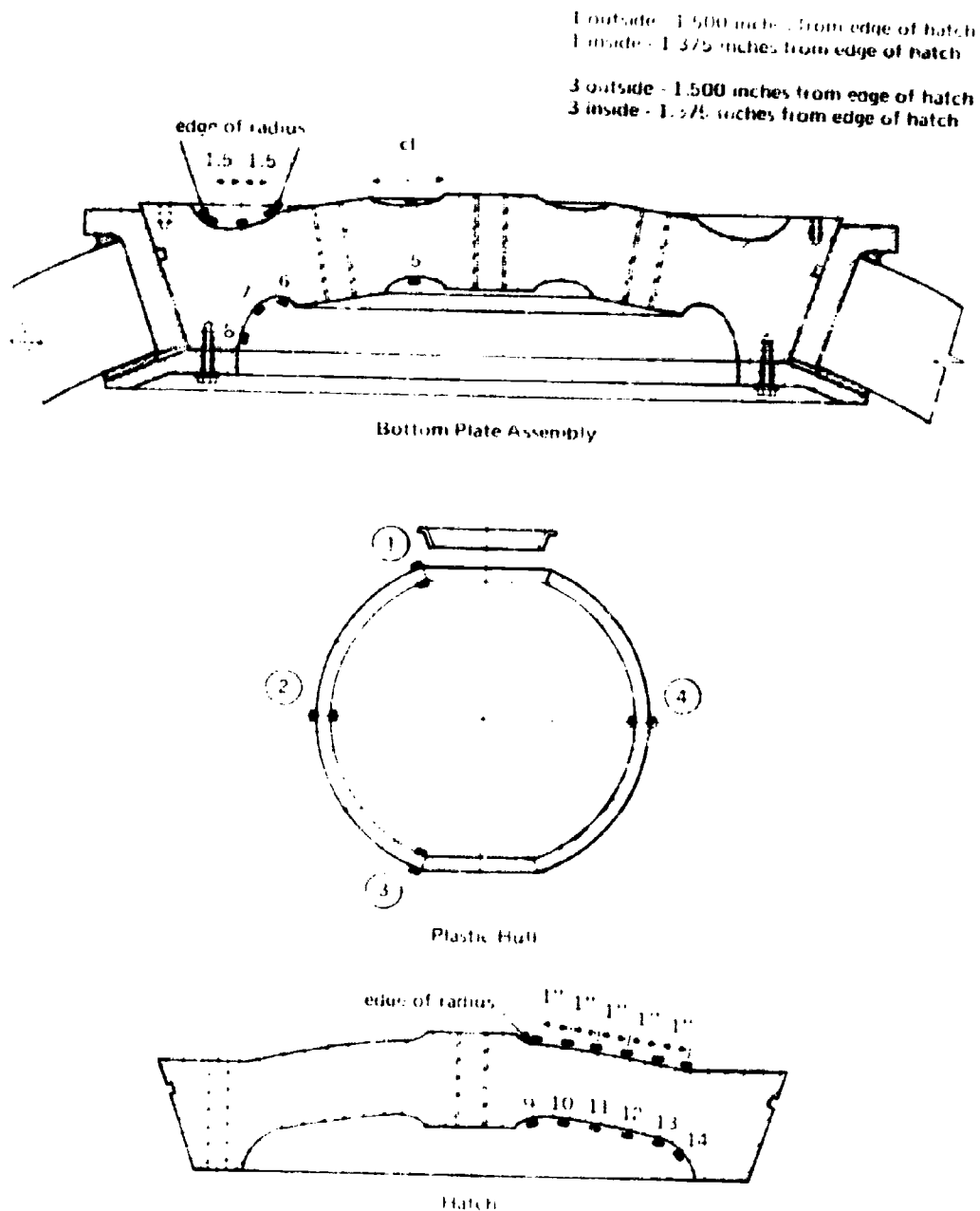


Figure 23. Location of strain gages on the 66 inch OD x 58 inch ID full scale Model 2000 Nemo Hull assembly.



Figure 24. Fragments of the 15 inch OD x 13 inch ID Model 34 after implosion at 4750 psi.

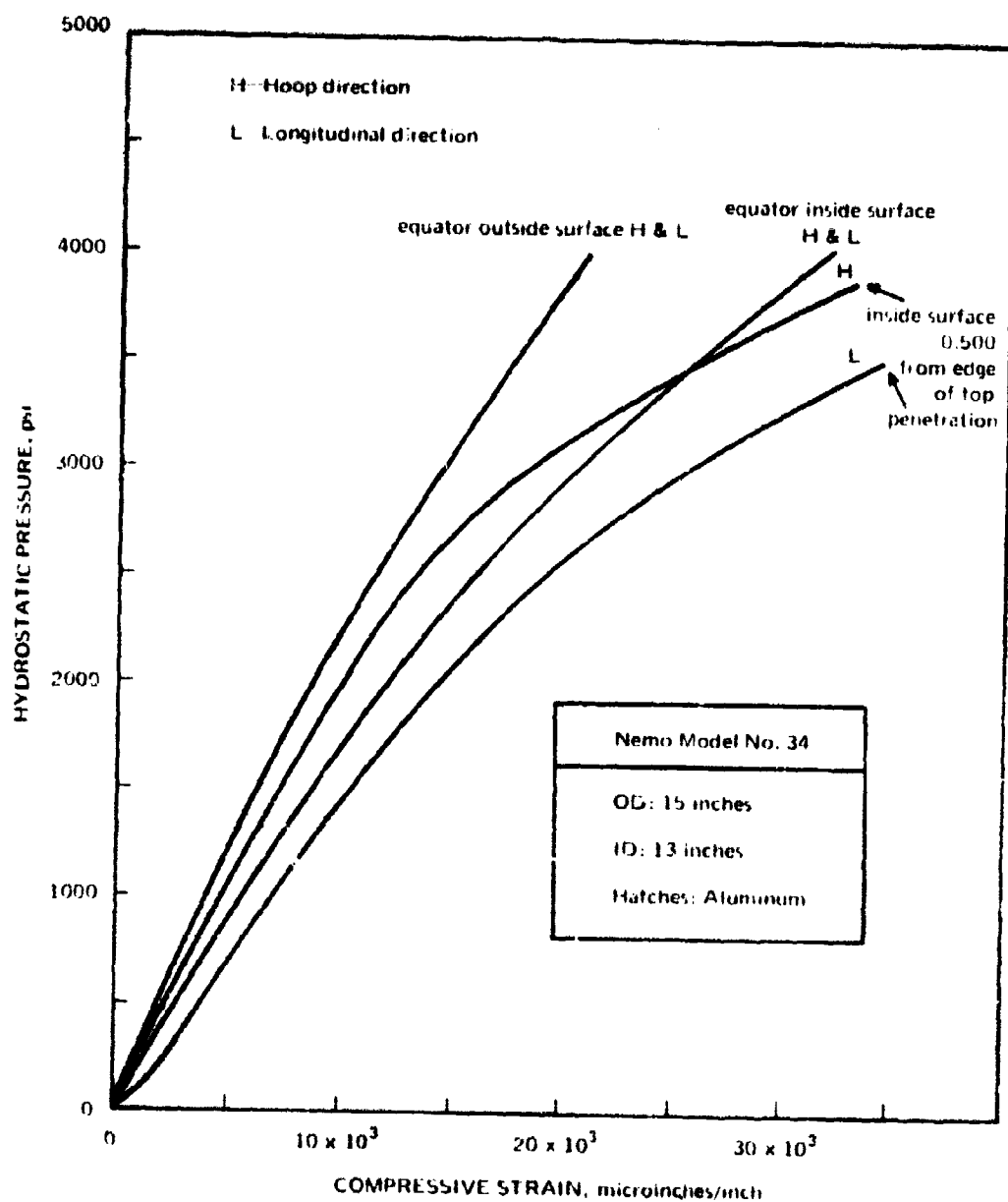


Figure 25. Strains in the 15 inch OD \times 13 inch ID Model 34 serving as scale for Model 2000 Nemo Hull.

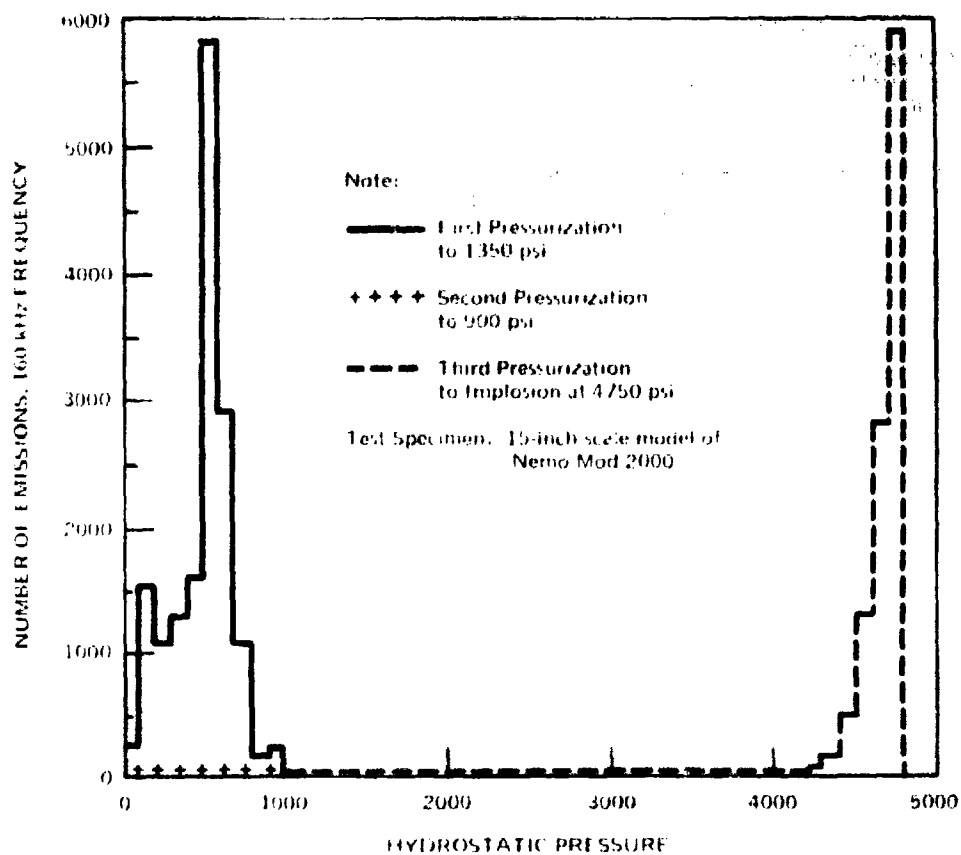


Figure 26. Histogram of stress wave emissions from 15 inch OD x 13 inch ID Model 34 of undergoing external pressure tests.

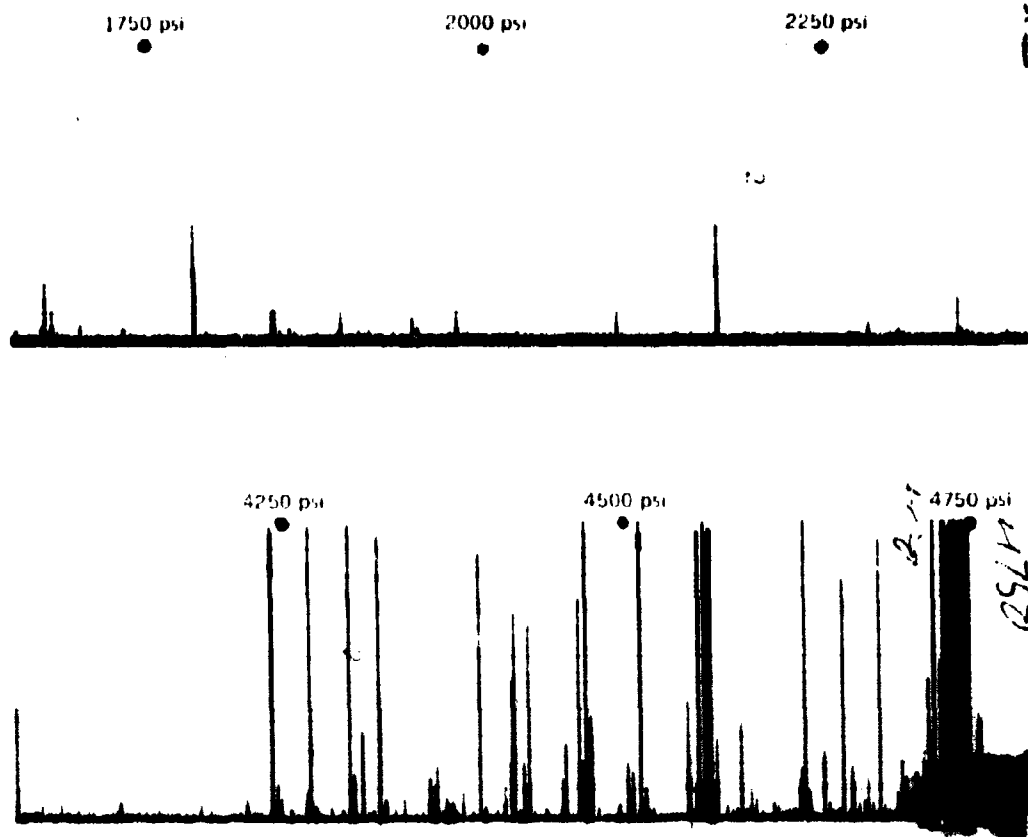


Figure 2.1. Recording of stress wave emissions preceding the short term implosion of 15 inch OD x 13 inch ID Model 34 assembly at 4750 psi external hydrostatic pressure.

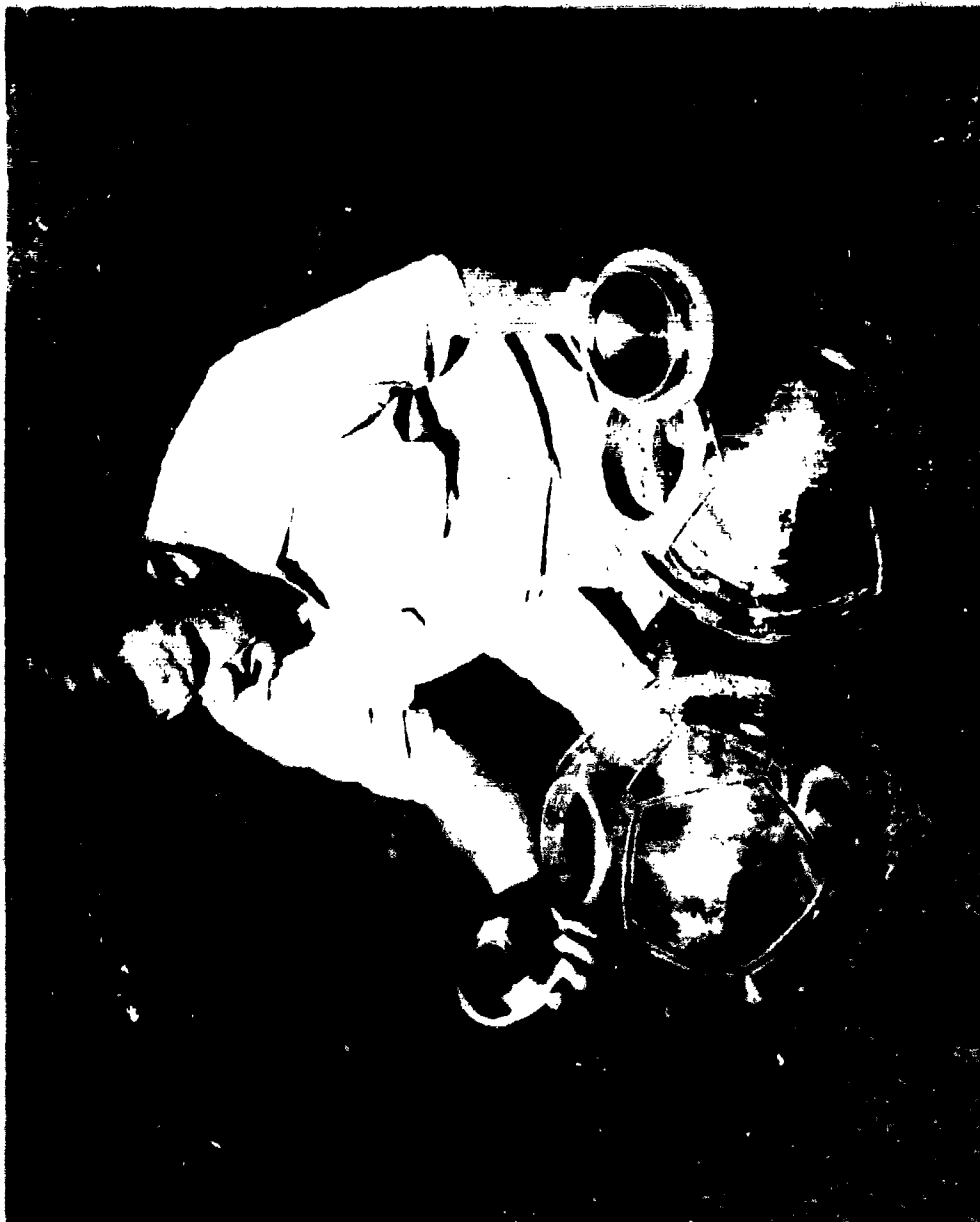


Figure 28. Inspection of bearing surfaces on 15 inch OD X 13 inch ID Models 36 and 37 after 1000 pressure cycles to, respectively, 900 and 1500 psi hydrostatic pressure.

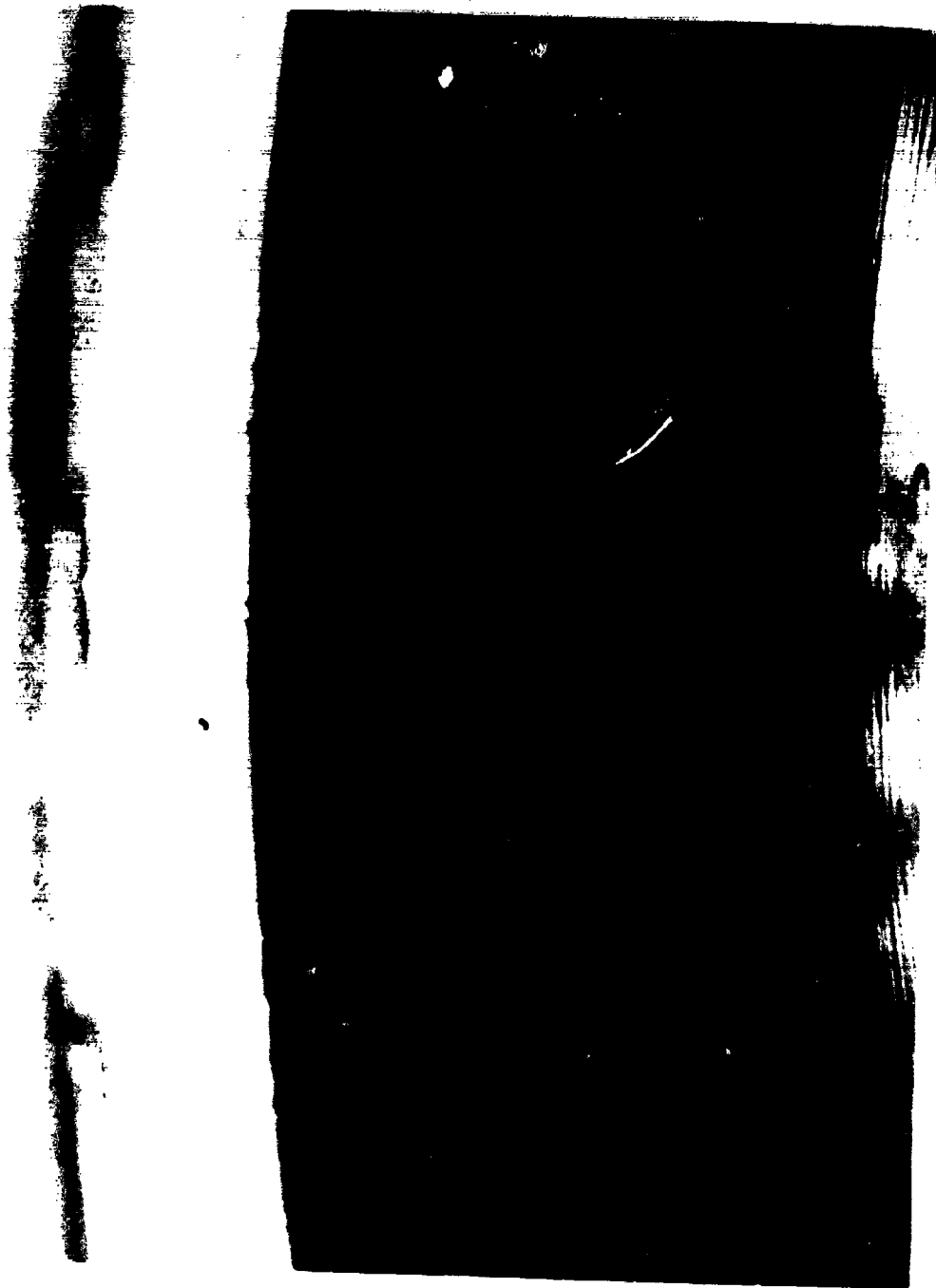


Figure 29. Fatigue crazing of the acrylic bearing surface of the Model 37 hull after 1000 pressurizations of 4 hour duration each to 1500 psi; this acrylic bearing surface was in direct contact with the metallic hatch.

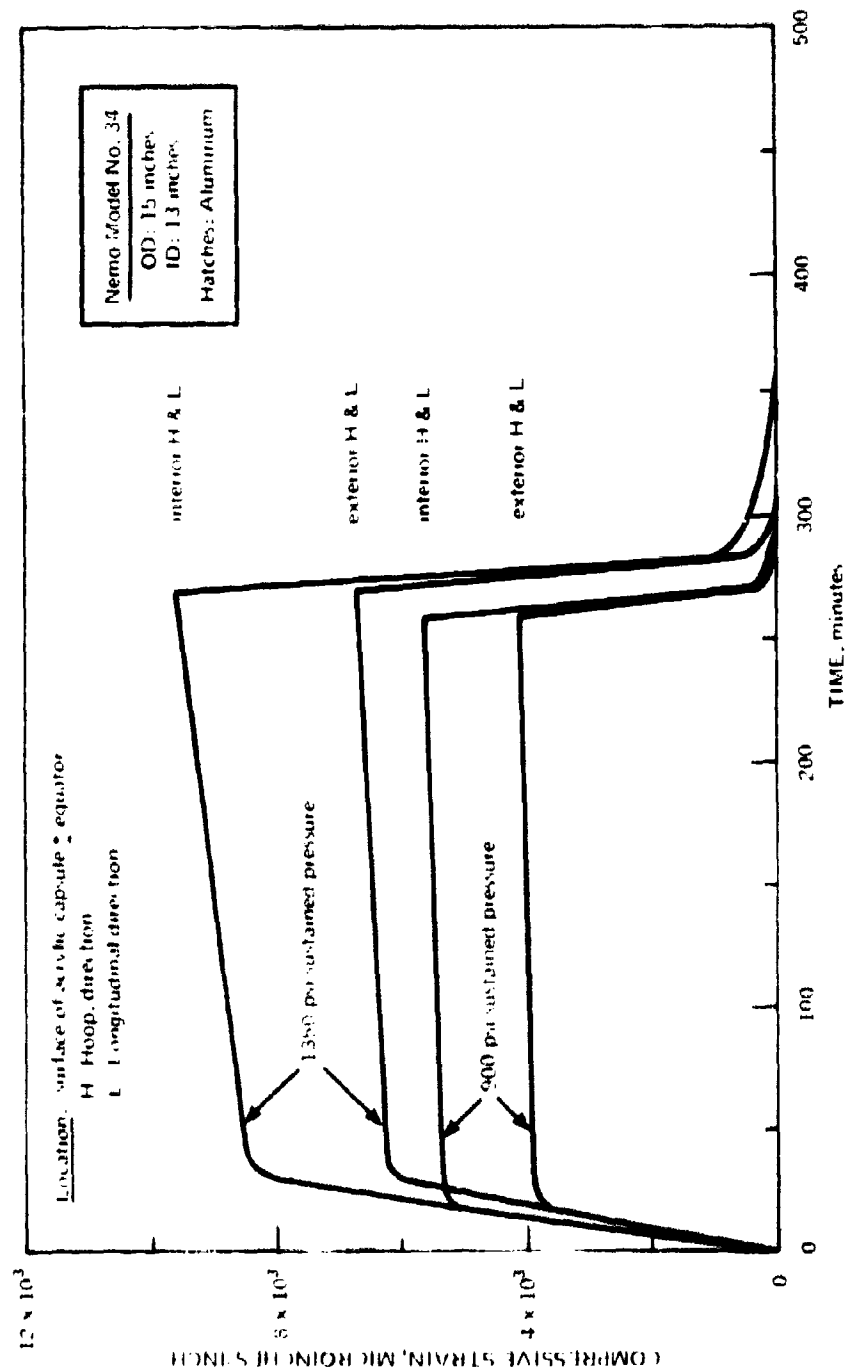


Figure 30. Creep of acrylic hull in 15 inch OD x 13 inch ID Model 34 under external hydrostatic pressure; measured on the interior and exterior surfaces at the equator.

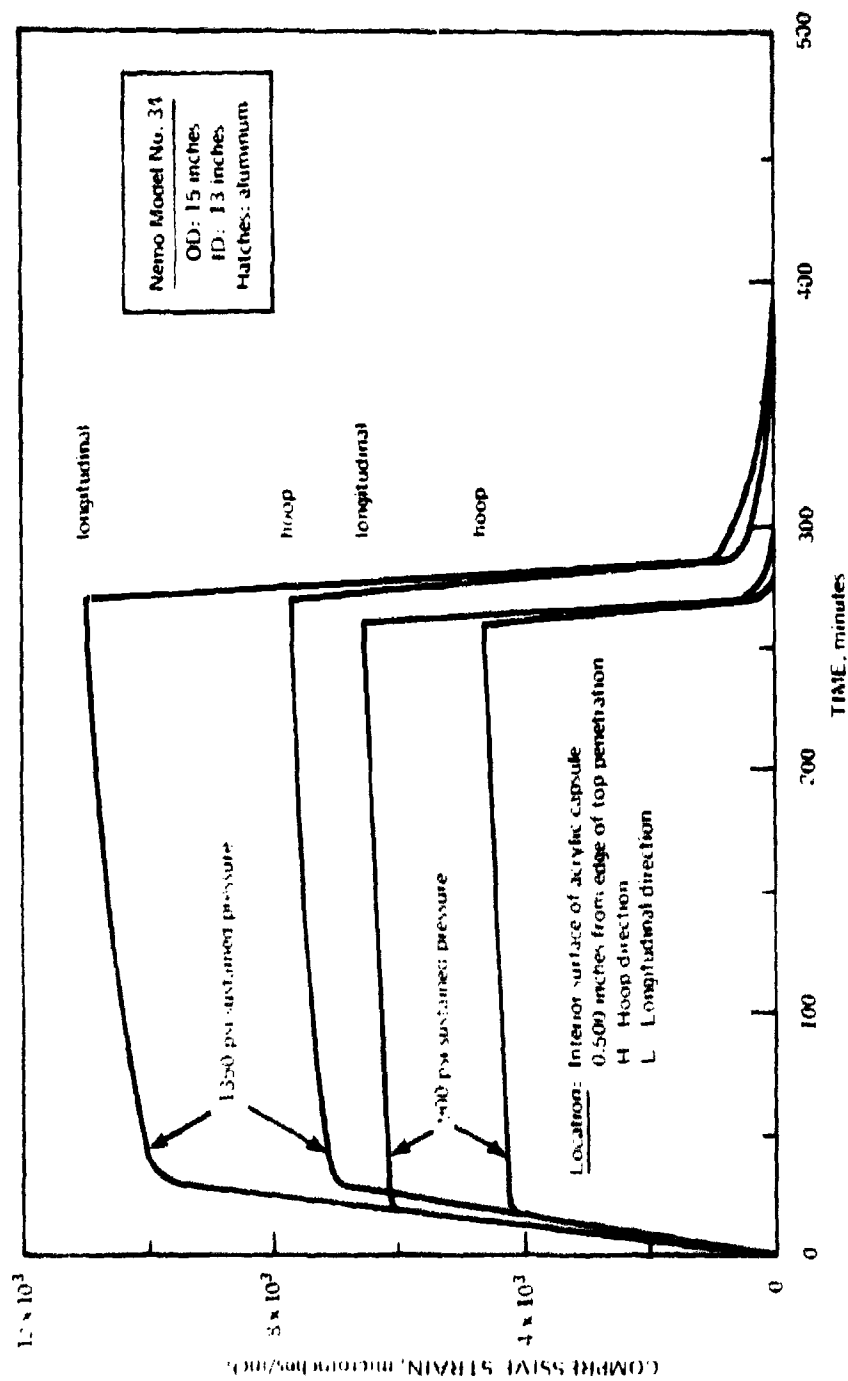
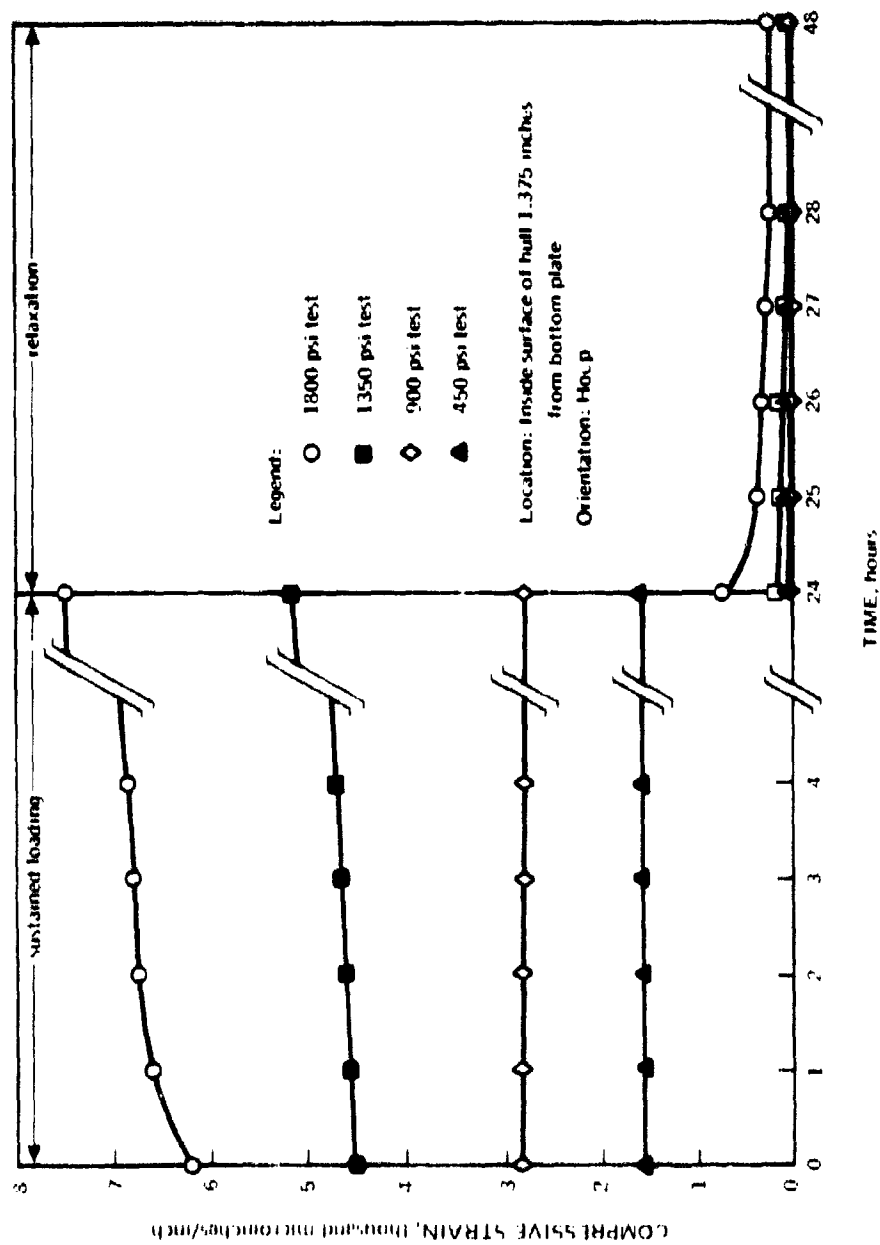
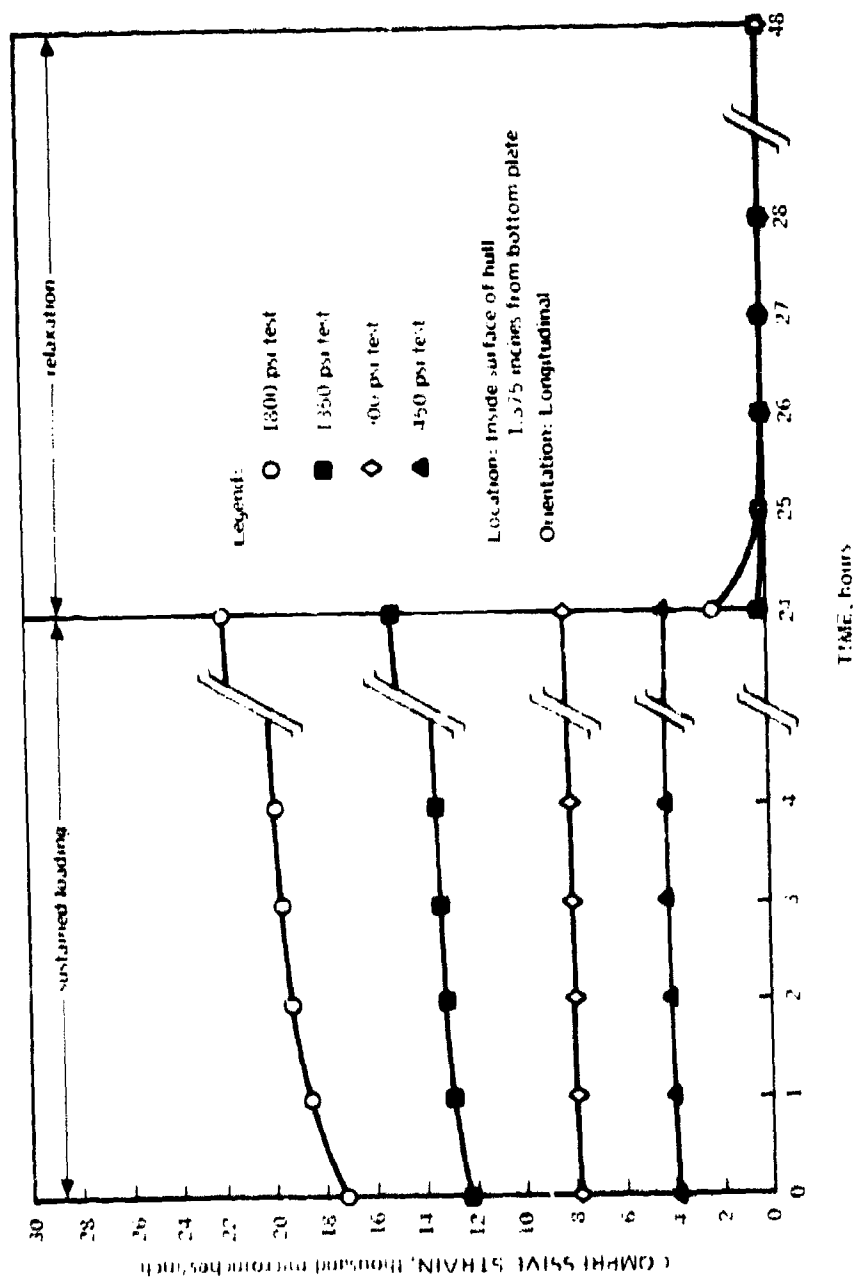


Figure 31. Creep of acrylic hull in 15 inch OD x 13 inch ID Model 34 under external hydrostatic pressure; measured on the interior surface at the edge of top polar penetration.



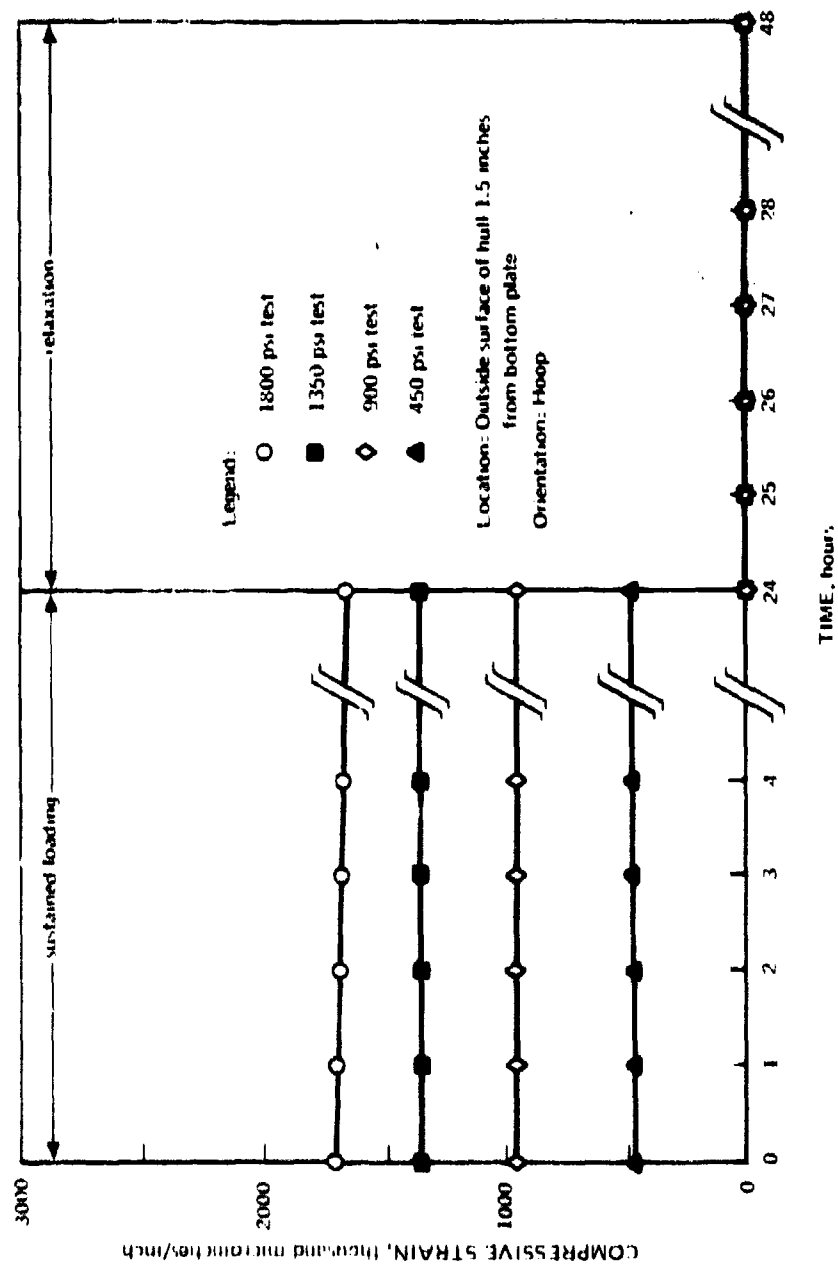
1.0 inside surface: 1.375 inches from edge of bottom plate: hoop

Figure 32. Creep measured on the acrylic hull of the 60 inch OD x 58 inch ID Model 2000 Nemo Hull assembly during 24-hour long sustained loadings under external hydrostatic pressure.



(b) inside surface, 1.575 inches from edge of bottom plate, longitudinal

Figure 32. (Continued).



(c) outside surface: 1.500 inches from edge of bottom plate: *hoop*

Figure 3.2.1 (Continued).

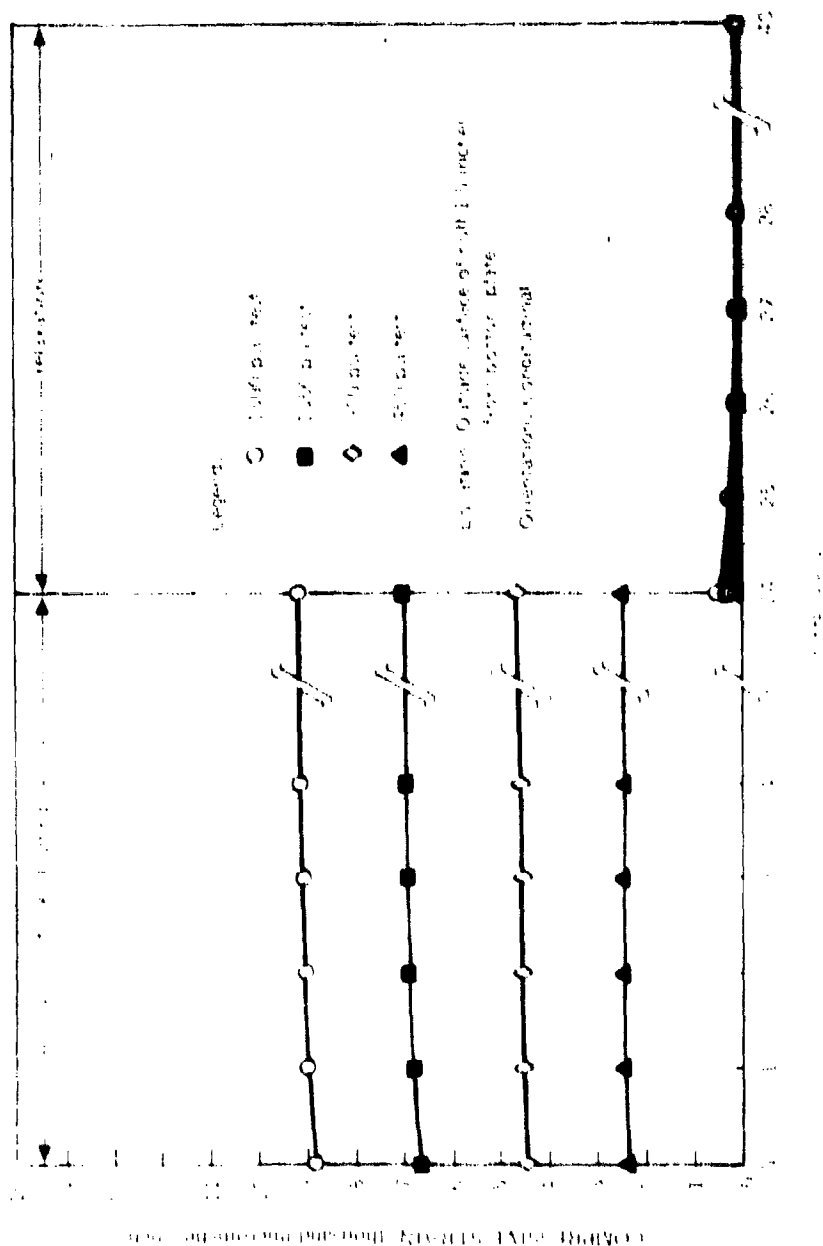
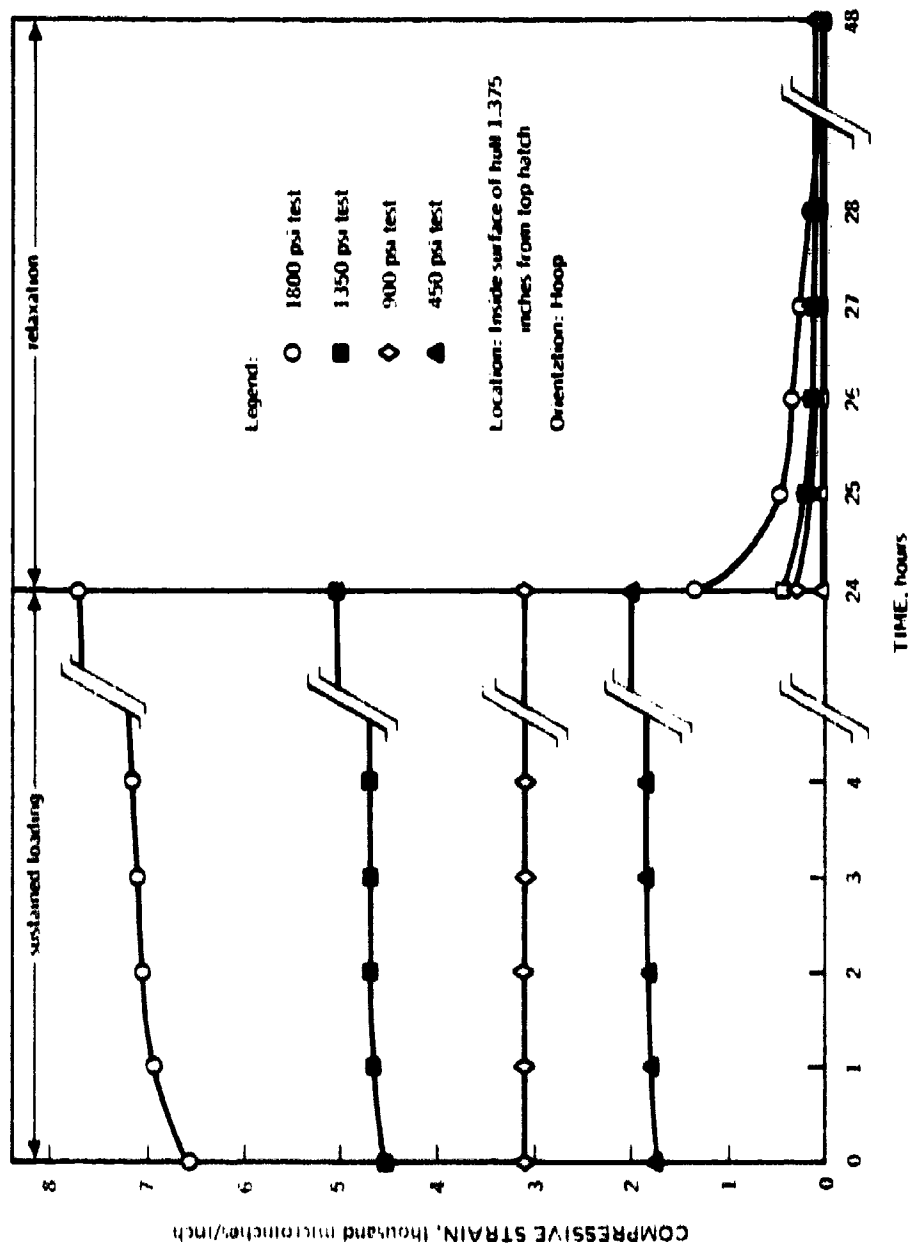


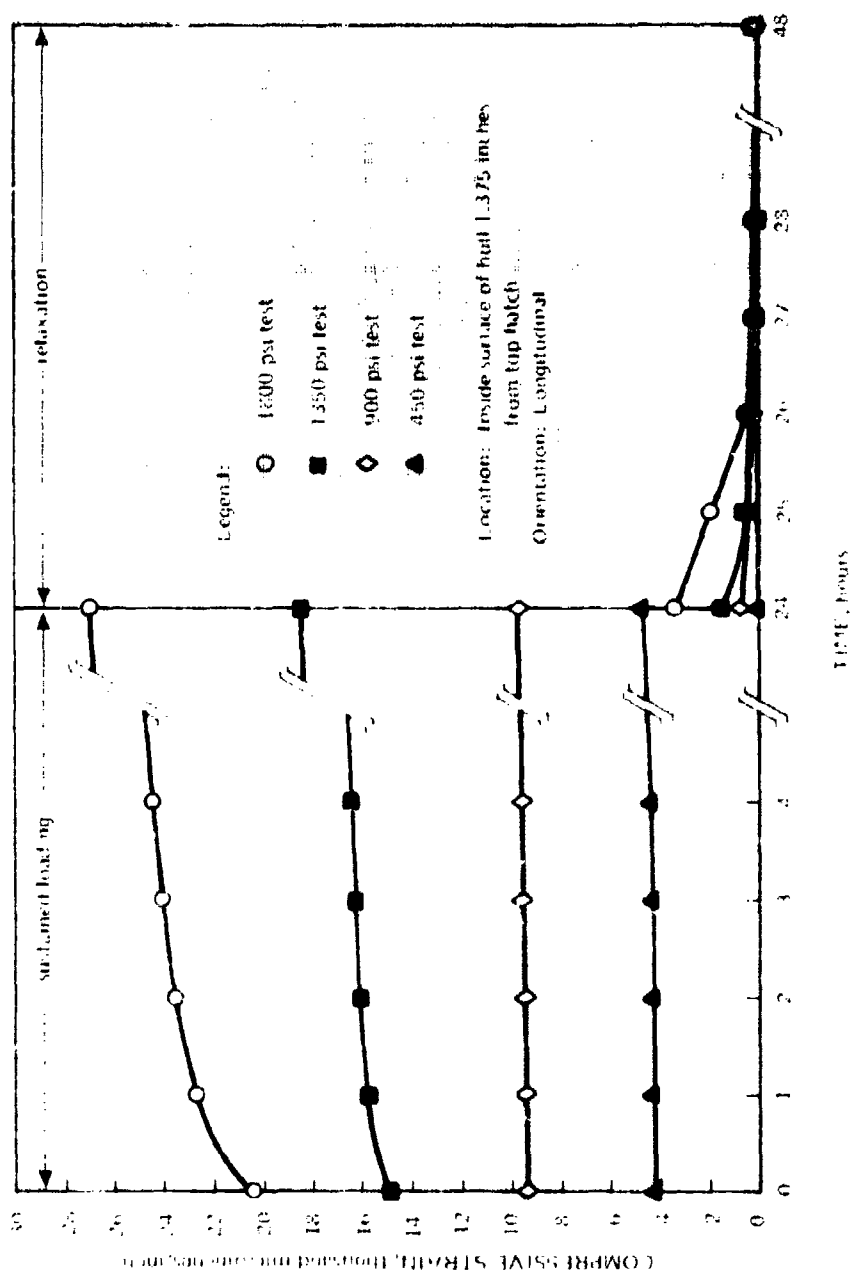
Fig. 12. Effect of Na_2CO_3 on the rate of polymerization of $\text{Na}_2\text{S}_2\text{O}_8$ in the presence of Na_2CO_3 .

Fig. 12. Continued.



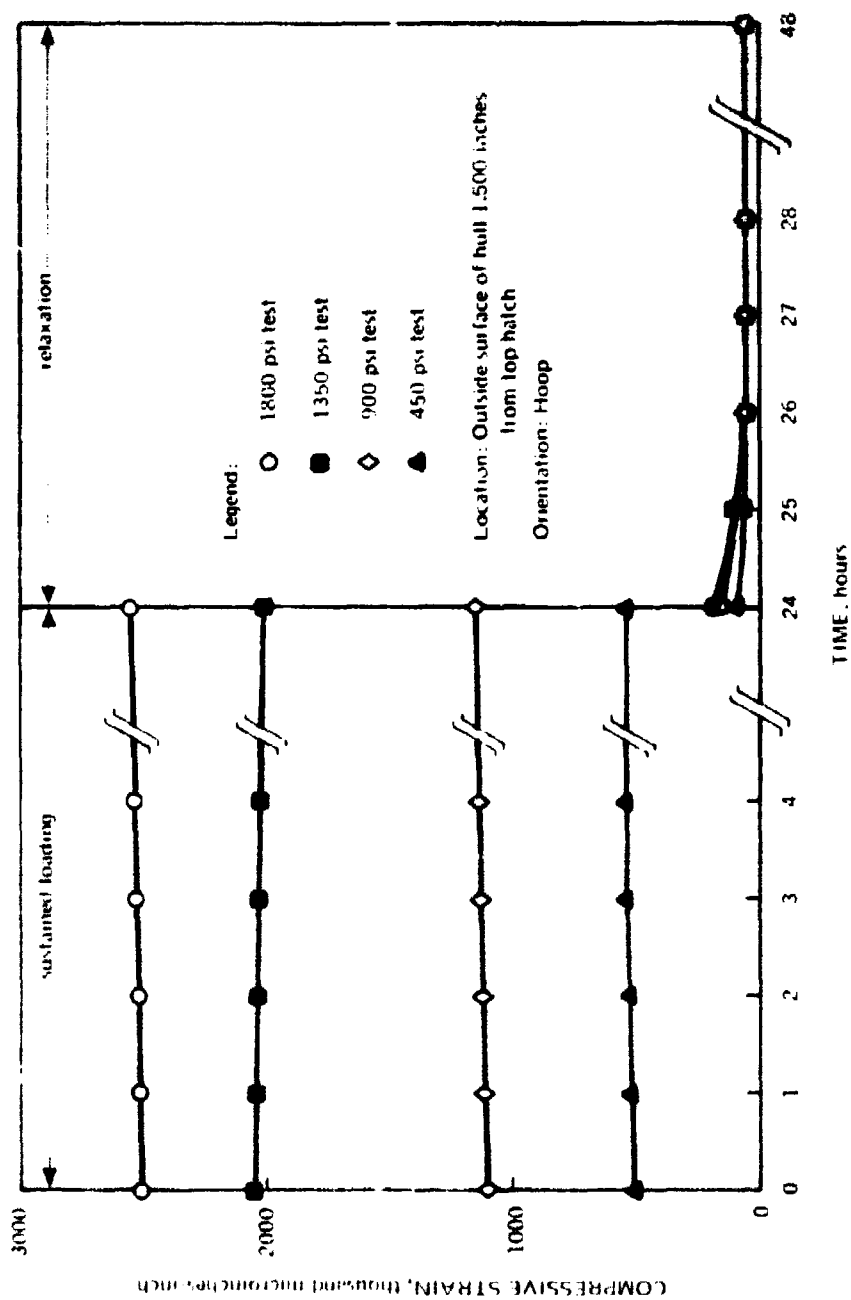
(e) inside surface: 1.375 inches from edge of top hatch: *hoop*

Figure 32. (Continued).



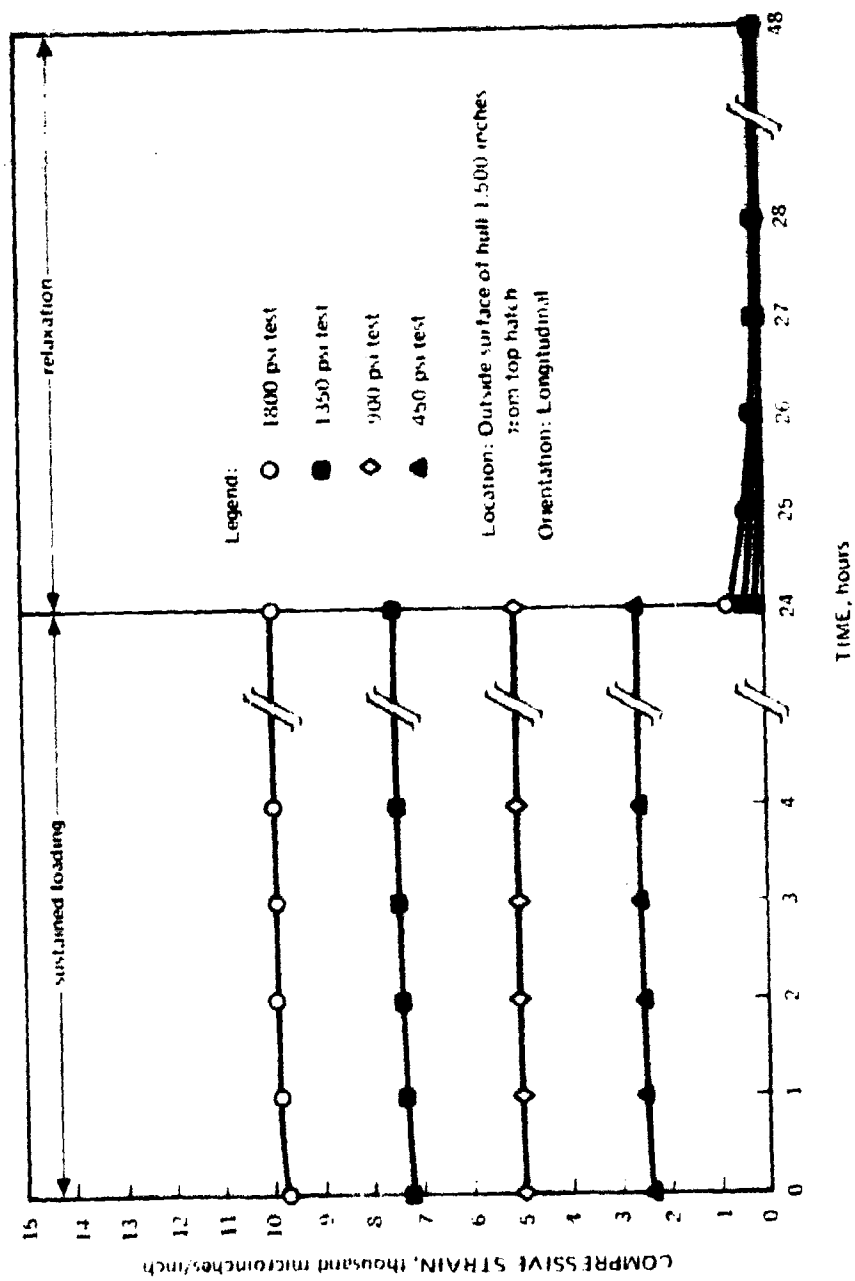
of inside surface: 1.375 inches from edge of top hatch: longitudinal

Figure 32. (Continued)



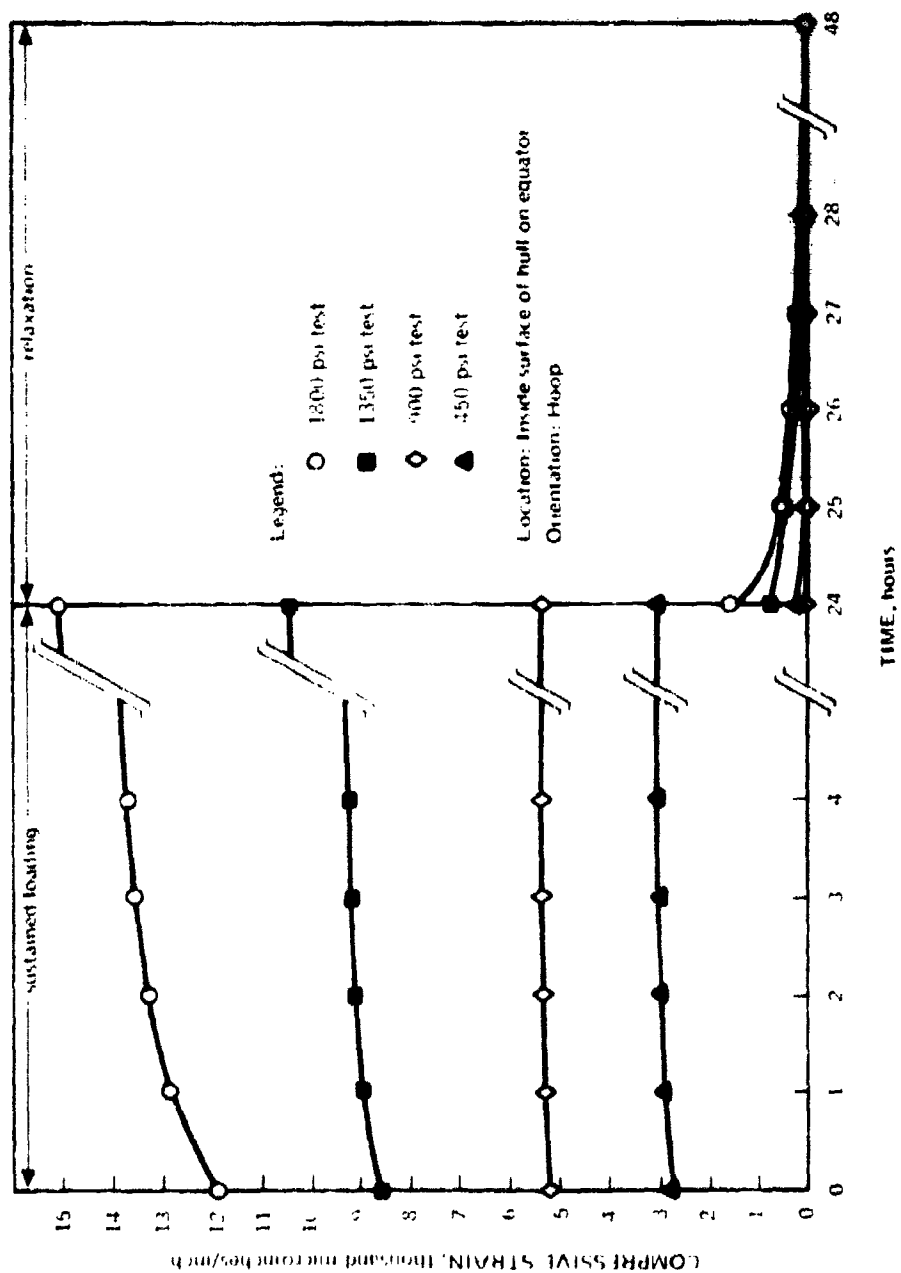
(g) outside surface: 1.500 inches from edge of top hatch: hoop

Figure 32. (Continued).



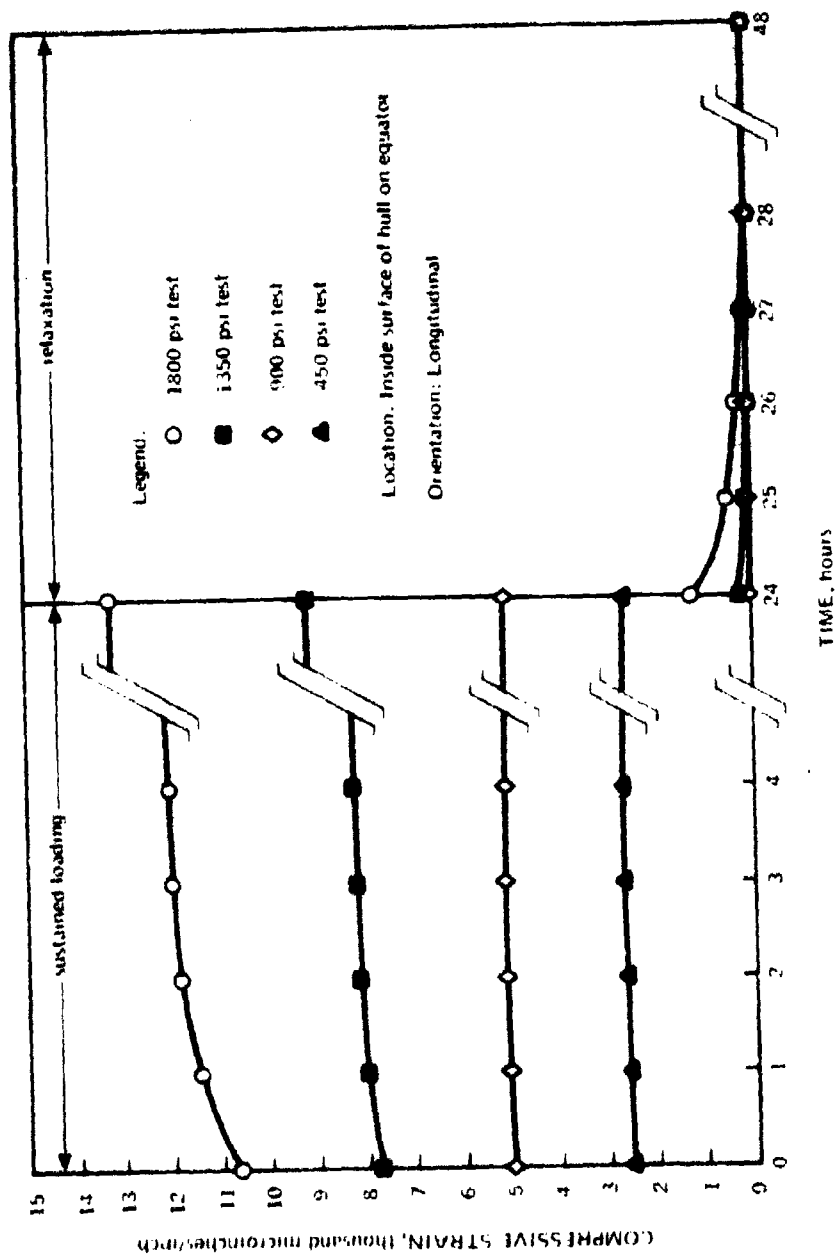
(h) outside surface: 1.500 inches from edge of top hatch: longitudinal

Figure 32. (Continued).



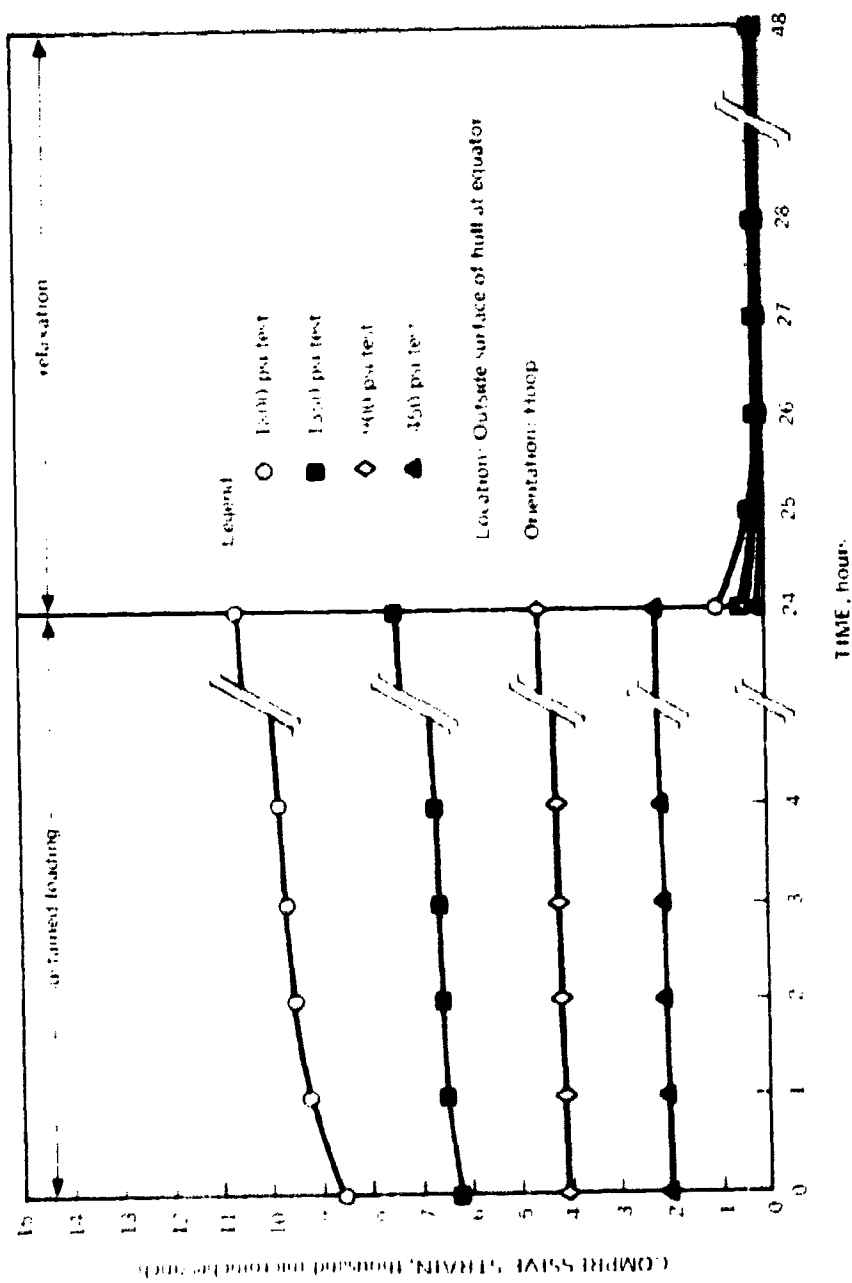
(c) inside surface: equator, hoop

Figure 32. (Continued).



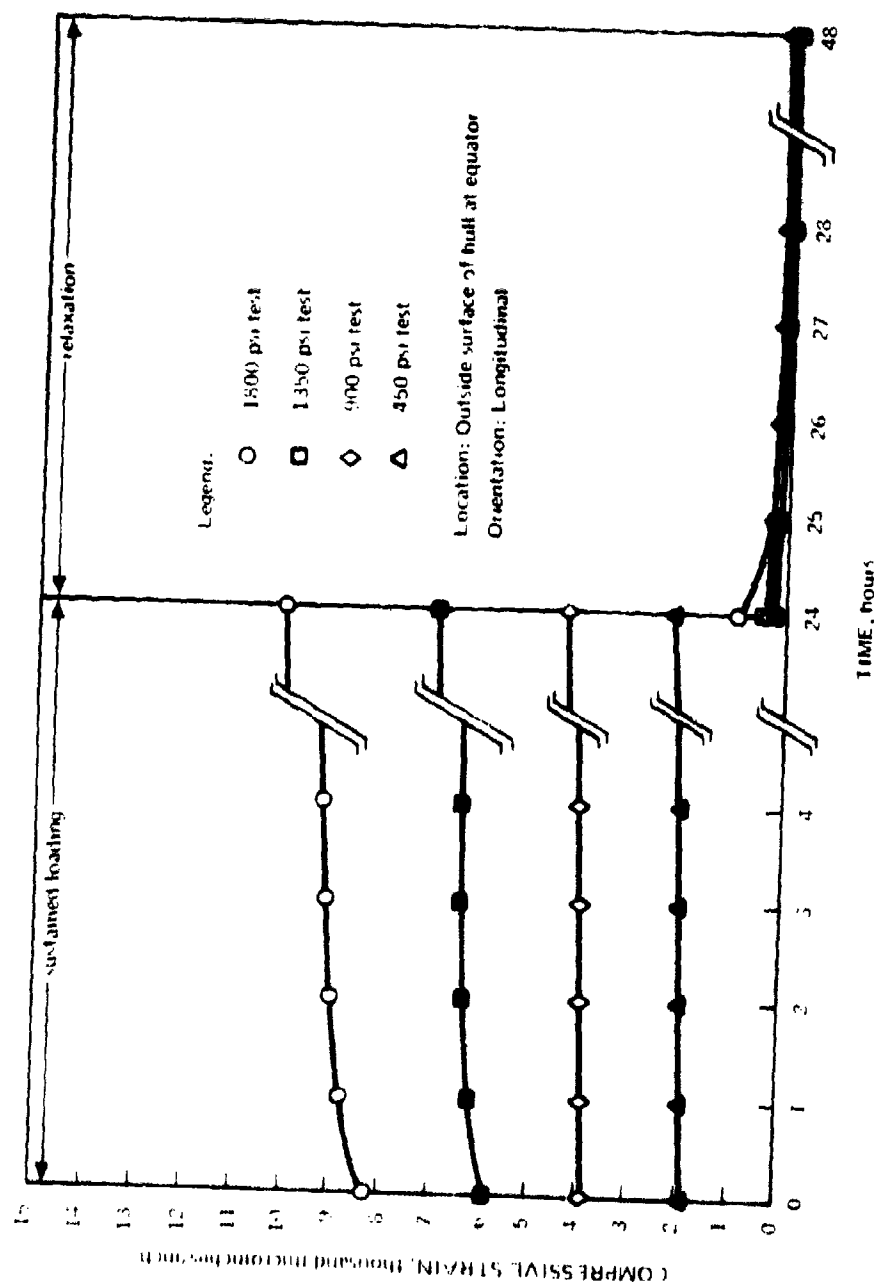
(i) inside surface; equator; longitudinal

Figure 32. (Continued).



(k) outside surface, equator, hoop

Figure 32. (Continued).



(b) outside surface, equator, longitudinal

Figure 32. (Continued).

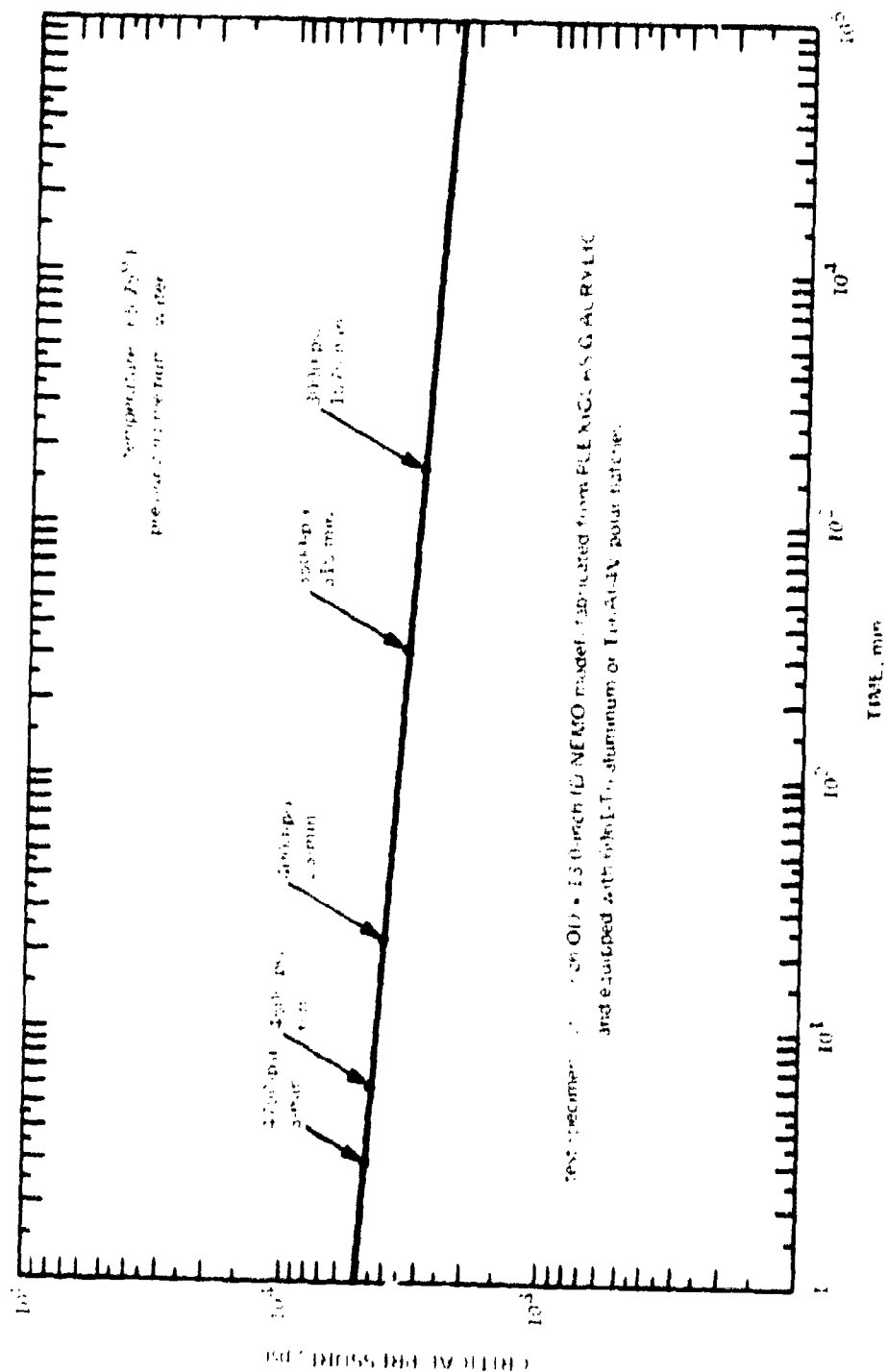


Figure 33. Long term critical pressure as a function of sustained loading duration.



Figure 34. Typical shear cracks in the bearing surface of an acrylic Nemo Hull generated by pressure cycling; when the cracks reach this size the acrylic hull should be removed from service and the bearing surface refinished. (Ref. 5, Nemo Hull Model 640 after pressure cycling to 2000 ft. depth.)

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4. Naval Civil Engineering Laboratory, Technical Note N-1094, "The Spherical Acrylic Pressure Hull for Hydrospace Application, Part 3: Comparison of Experimental and Analytical Stress Evaluations for Prototype NEMO Capsule," H. Ottson, March 1970 (AD 709914).
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9. American Society of Mechanical Engineers, Paper No. 72-WA-OC1-8, "Transparent Hull Submersible MAKAKAI," by D. W. Murphy and W. L. Mazzone, December 1972.
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11. Naval Civil Engineering Laboratory, Technical Report R-716, "Structural Analysis of a Full Scale Spherical Acrylic Plastic Pressure Hull," M. R. Snoey and M. G. Katona, March 1971.

12. American Society of Mechanical Engineers, Paper No. 70-WA UnT-4, "Fabrication of NEMO-Type Spherical Acrylic Capsules for Underwater Vehicles," K. Tsuji and R. Shelton, December 1970
13. American Society of Mechanical Engineers, Paper No. 71-UnT-2, "Acrylic Pressure Hull for Submersible NEMO," by J. D. Stachiw, December 1970
14. American Society of Mechanical Engineers, Paper No. 70-UnT-B, "Stress Analysis of a Spherical Acrylic Pressure Hull," by M. R. Snoey and M. G. Katona, December 1970
15. American Society of Mechanical Engineers, Paper No. 70-UnT-A, "Optical Properties of a Spherical Plastic Underwater Observatory NEMO," by L. Frowbridge, December 1970
16. American Society of Mechanical Engineers, Paper No. 72-WA OCT-11, "Modulated Light Beam Information Transmission System for Transparent Pressure Hulls," by J. F. Holzschuh and G. R. Beaman, December 1972

APPENDIX A. DESIGN DETAILS OF NEMO MODEL 2000

15-Inch OD \times 13-Inch ID Scale Models

The acrylic hull of the 15-inch OD \times 13-inch ID scale model 34 was designed to be a faithful copy of the 66-inch OD \times 58-inch ID Model 2000 Nemo Hull both in proportions and in method of construction (Figures 1A and 2A). It was to be fabricated in the same manner as the 66-inch OD \times 58-inch ID hull by thermoforming spherical sectors from flat discs, machining pentagons from sectors, and finally assembling the spherical pentagons into a sphere by bonding the joints between adjoining pentagons with PS-30 self-polymerizing adhesive (Figure 3A).

The aluminum plates (Figures 4A, 5A, and 6A) for top and bottom polar openings in the 15-inch OD \times 13-inch ID Model 34 were not faithfully scaled down models of the hatches in the 66-inch OD \times 58-inch ID diameter Model 2000 Nemo Hull. Although structurally the 6061-T6 aluminum plates in the 15-inch OD \times 13-inch ID Model 34 behave identically to the hatches in the 66-inch OD \times 58-inch ID hull, some operational features of the large hatches have been omitted in the scale model plates. Thus, for example, the top aluminum plate 15-inch OD \times 13-inch ID Model 34 has the same rigidity and proportions as the top hatch in the 66-inch OD \times 58-inch ID Model 2000 Nemo Hull but does not disassemble into separate hatch and hatch ring components.

The construction of the 15-inch OD \times 13-inch ID Models 35, 36, and 37 was identical to that of Model 34. The only difference between Model 34 and the other models lay in the design of the polar plates. The polar plates for Models 35, 36, 37 were structurally idealized hatches designed in titanium Ti-6Al-4V (Figure 7A). Since these models were to be used in cyclic pressure tests to determine the effect of depth on the performance of the polycarbonate gasket between the hatch and the acrylic bearing surface, each model was equipped with the polycarbonate gasket only for the top plate while the bottom plate in each model was designed to operate without a gasket. In this manner each model was designed to operate both with and without a gasket around the titanium plates. In this manner, each model would provide the data on the performance of acrylic bearing surfaces at a given pressure with and without polycarbonate gaskets (Figure 8A).

66-Inch OD \times 58-Inch ID Operational Model

The 66-inch OD \times 58-inch ID operational Model 2000 Nemo Hull was designed for economical construction within tight dimensional tolerances to maximize the operational depth of the assembly. The acrylic hull was designed to be constructed from 12 spherical pentagons bonded together with PS 18, PS 30 or any other self-polymerizing adhesive with 5000 psi minimum tensile strength (Figures 9A and 10A).

The polar aluminum assemblies were designed, like the polar insert assemblies in the previous Model 600 and Model 1000 Nemo Hulls, to serve as hatches for personnel entry and feed-through plates for electrical and hydraulic control cables. Aluminum was chosen as the

construction material because of its resistance to corrosion and attractive strength to weight ratio. The bottom feed through plate was equipped with 9 holes to accommodate 9 separate electrical or hydraulic feed throughs (Figure 11A). In addition, the feedthrough plate serves also as the foundation for any equipment contained within the capsule. The diameter of the top polar opening was selected to be ample enough even for a heavy set pilot or observer (Figure 12A). Because considerable exertion has been required of the crew in the past Nemo Hull designs to open the heavy hatch, a set of torsion springs was incorporated into the Model 2000 Nemo hatch assembly (Figure 12A). Also latch locks have been incorporated into the hatch handles to lock them securely in the open position when the hatch is open (Figure 13A).

All the parts of the hatch were made from 6061-T6 aluminum, except the Monel K-500 latch shafts, the 17-4 PH stainless hinge pin, steel counter balance springs, and polycarbonate plastic gaskets (Figures 14A, 15A, 16A, 17A, 18A, 19A and 20A). Materials chosen for these applications matched well with the galvanic potential of aluminum, thus preventing unduly severe galvanic corrosion. As a rule all the bevel angle tolerances on polar insert components were specified to be ± 15 minutes, a readily attainable tolerance with standard shop machining practices. During the subsequent assembly of the Model 2000 Nemo Hull structure it was found, however, that the ± 15 -degree angle tolerances resulted in incomplete surface contact between matching beveled structural components. As a result of this finding, it is recommended that the angle tolerance be decreased to ± 7.5 degrees in future Model 2000 Nemo Hull assemblies.

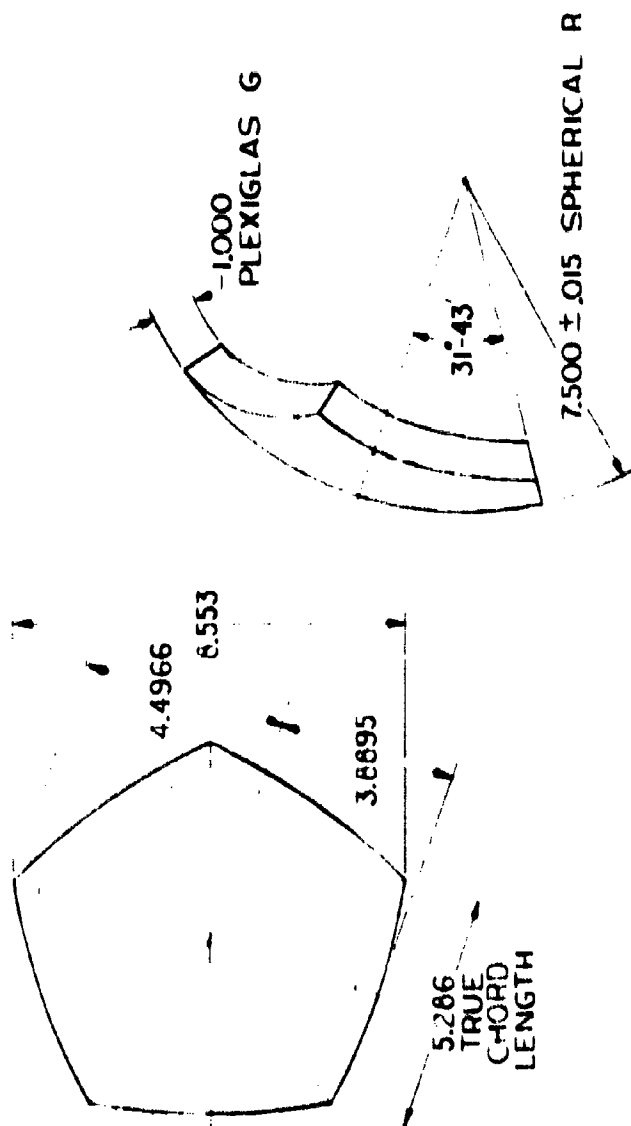
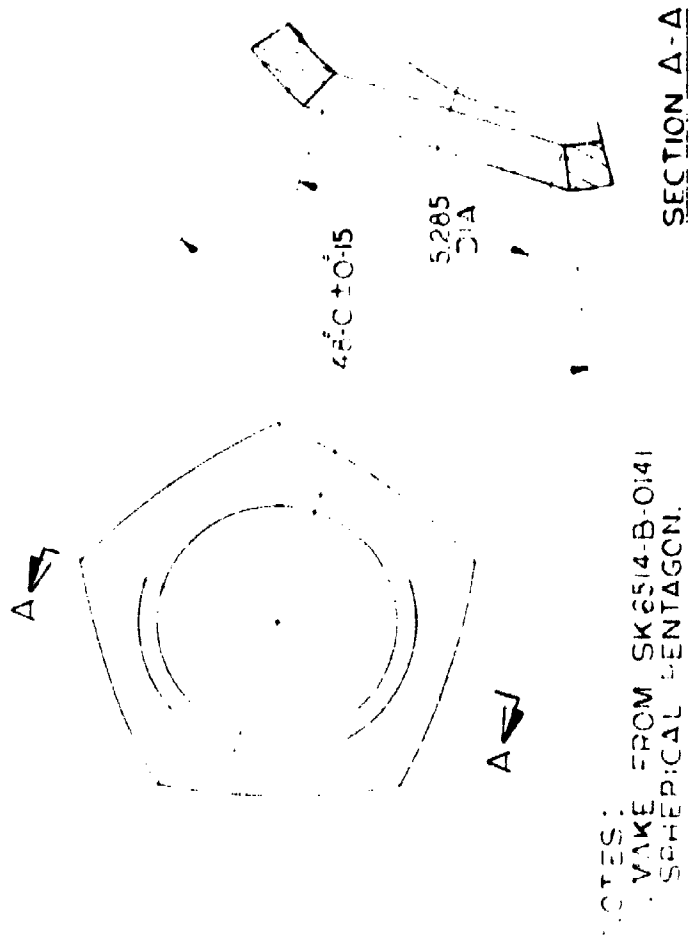
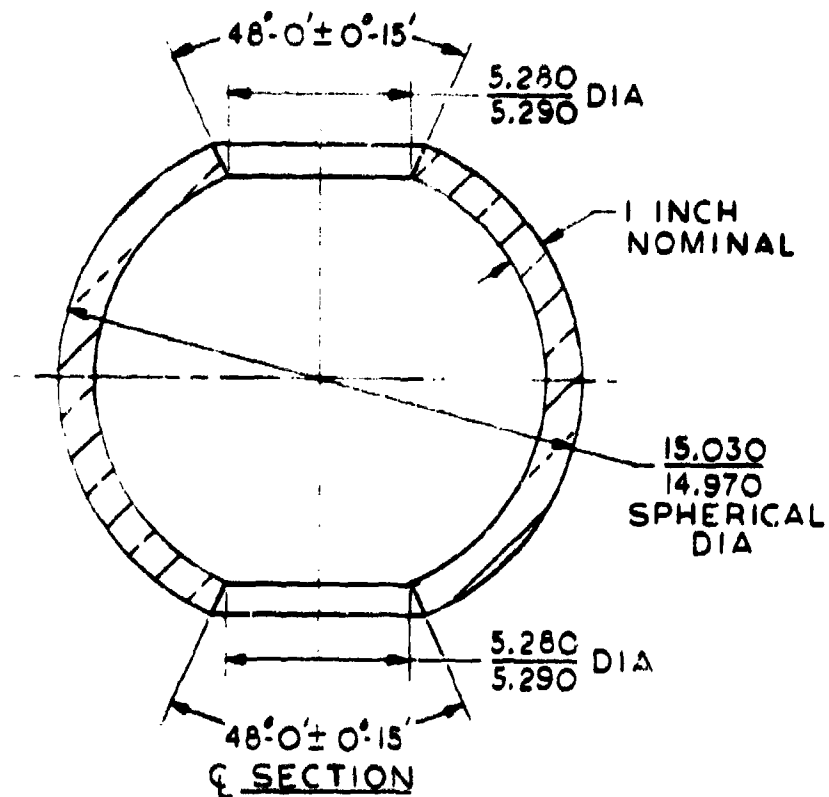


Figure 1A. Spherical pentagon for the 15-inch OD \times 13-inch ID scale model of the Model 2000 Nemo Hull.



NOTES:
 1. VAKE FROM SK6514-B-0141
 2. SPHERICAL PENTAGON.

Figure 2A. Polar spherical pentagon for the 15-inch OD x 13-inch ID scale model of the Model 2000 Nemo Hull.



NOTES :

1. MATERIAL : PLEXIGLAS G, 1.0 INCH PLATE
2. ADHESIVE : PS-30
3. POLAR INSERTS : ALUMINUM HATCHES
PER DWG 701100-II
POLYCARBONATE GASKETS
PER DWG 701100-II

Figure 3A. Assembled hull of the 15-inch OD x 13-inch ID Model 34

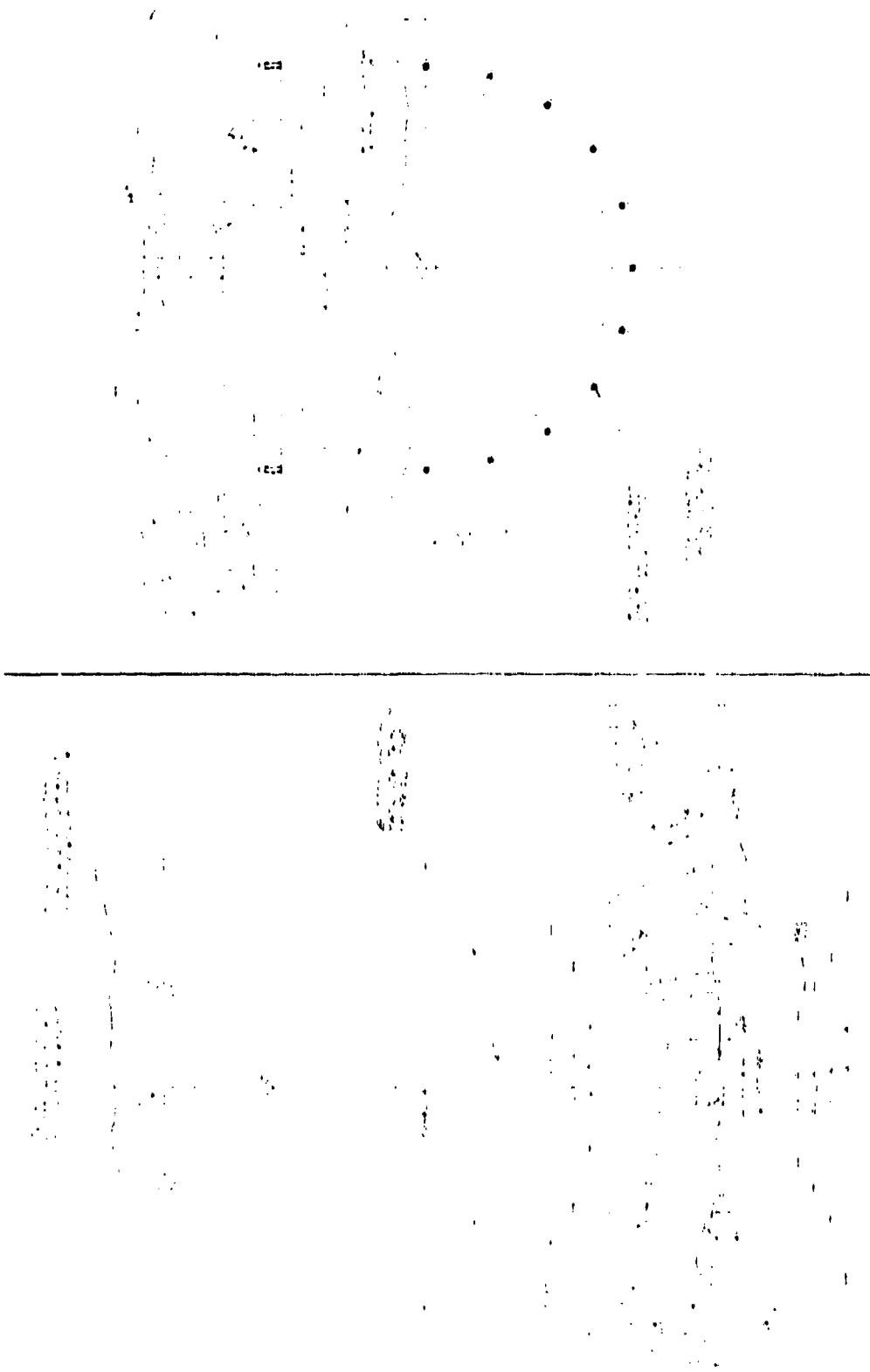


Figure 4A. Polar Aluminum Hatch Assemblies for the 15-inch OD x 13-inch ID Model 34.

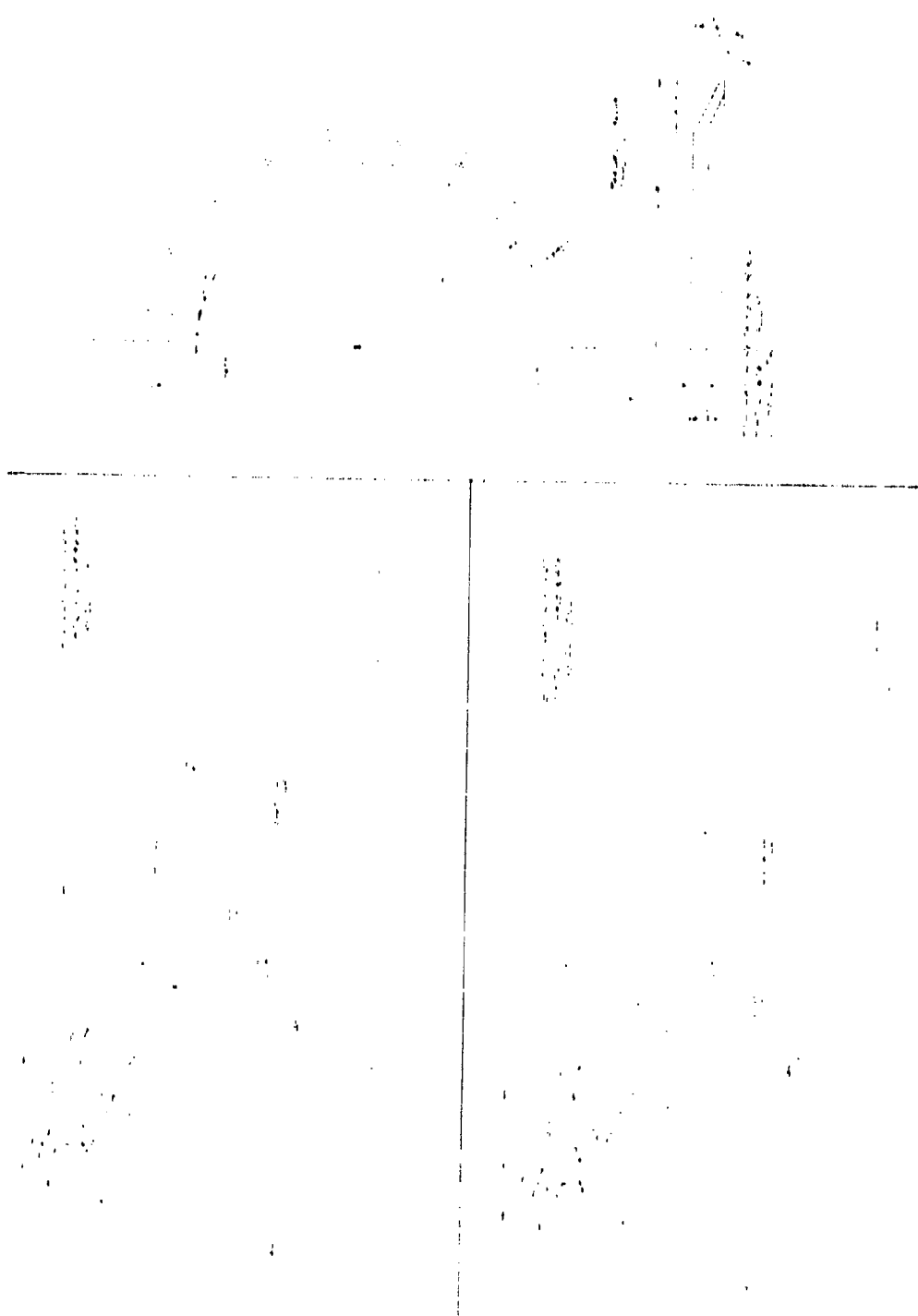


Figure 6A. Polycarbonate polar gaskets and top hatch retaining ring for the 15-inch OD - 13-inch ID Model 34.

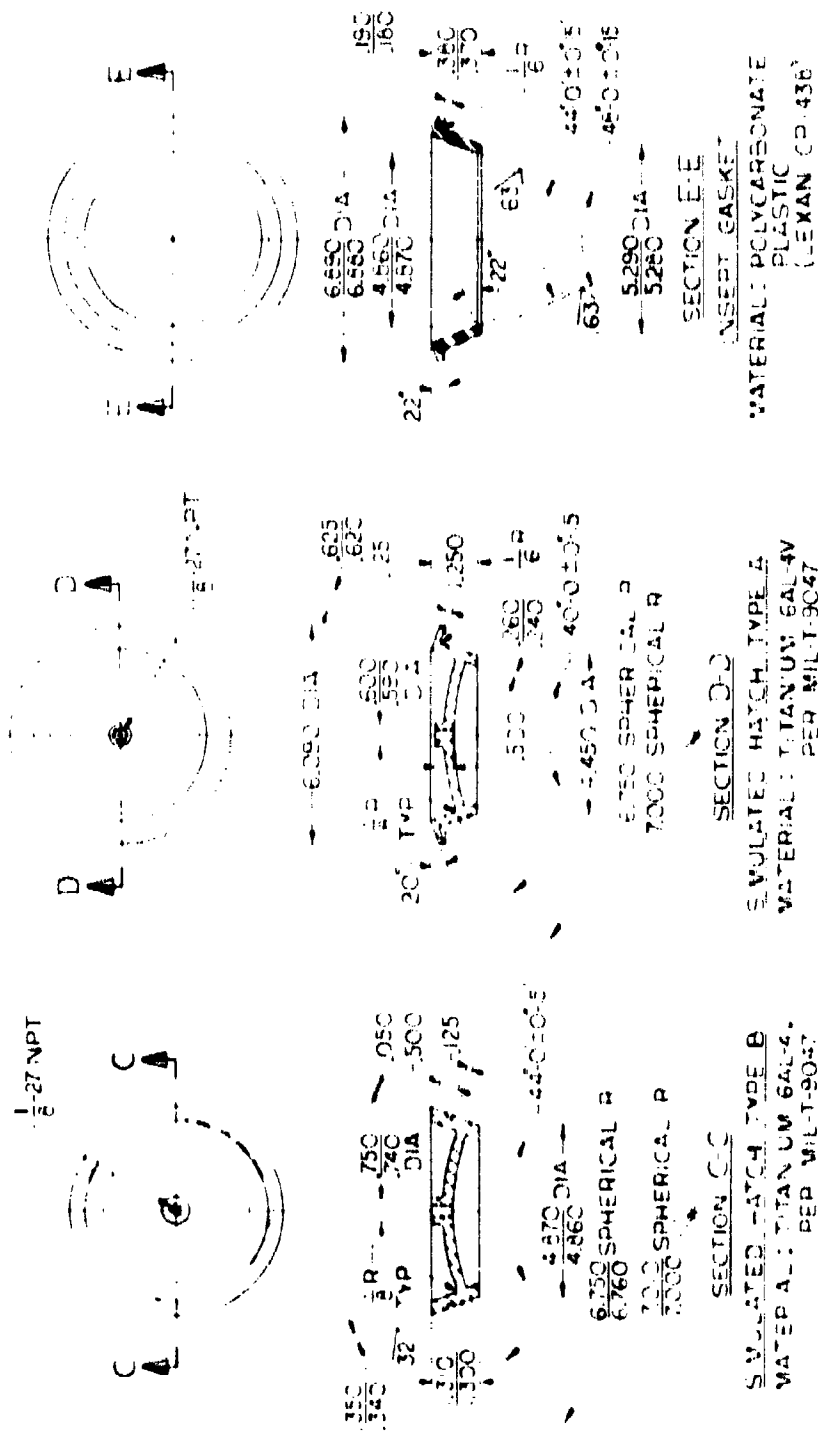


Figure 7A. Polar titanium hatches for service with 15-inch OD x 13-inch ID Models 35, 36 and 37. Note that Type A titanium hatch was designed for service without the polycarbonate gasket while Type B titanium hatch was designed to be used with a polycarbonate gasket.

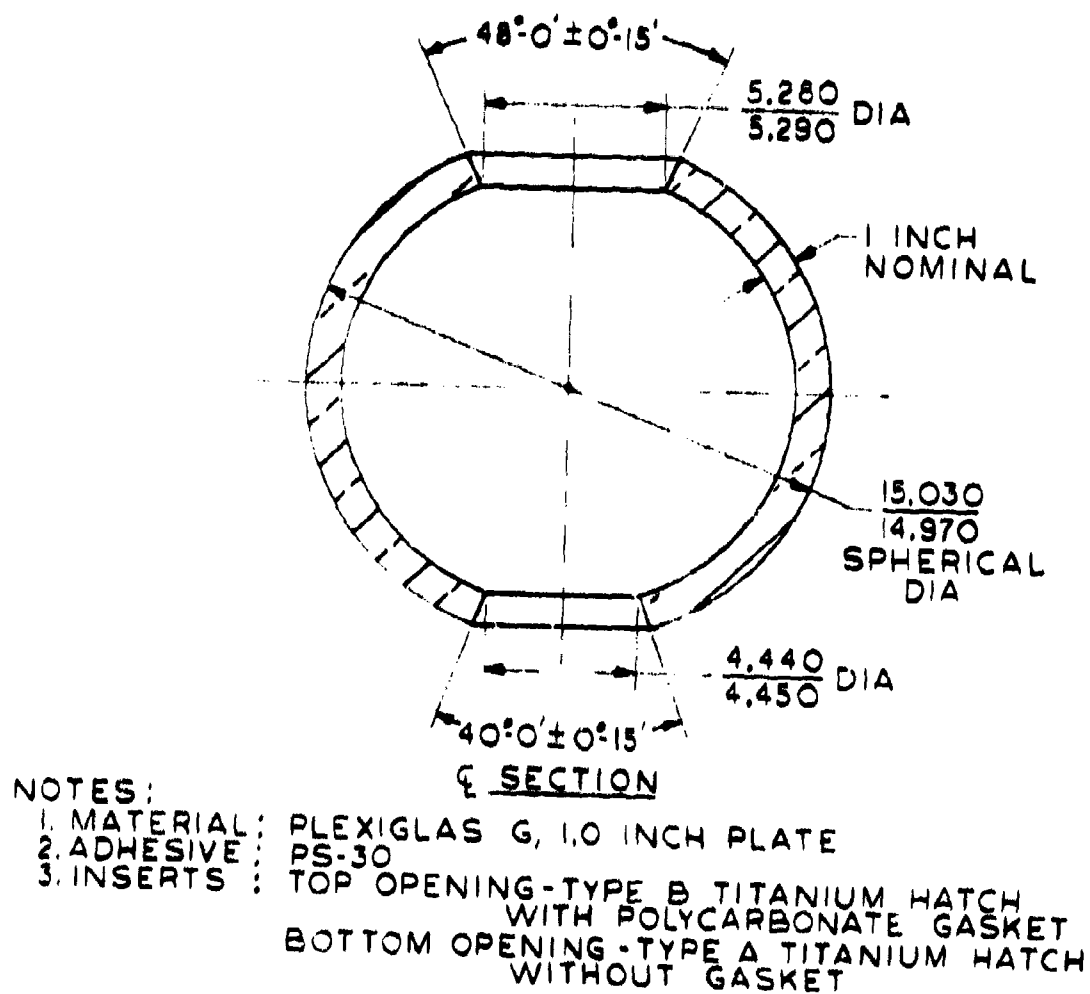


Figure 8A. Typical assembly of 15-inch OD \times 13-inch ID Models 35, 36 and 37.

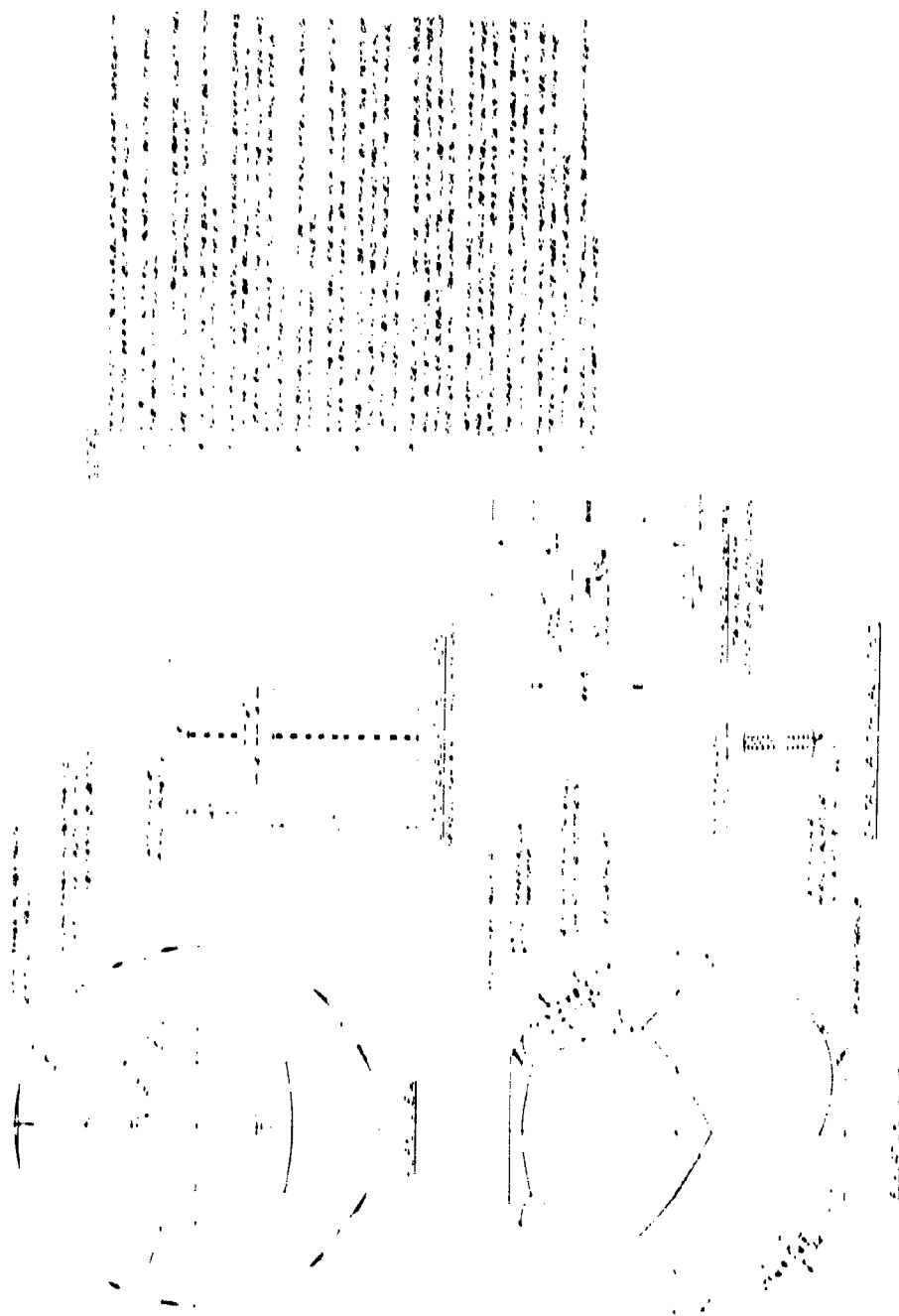


Figure 4A. Model 2000 acrylic Nemo Hull assembly, 60-inch OD x 58-inch ID.

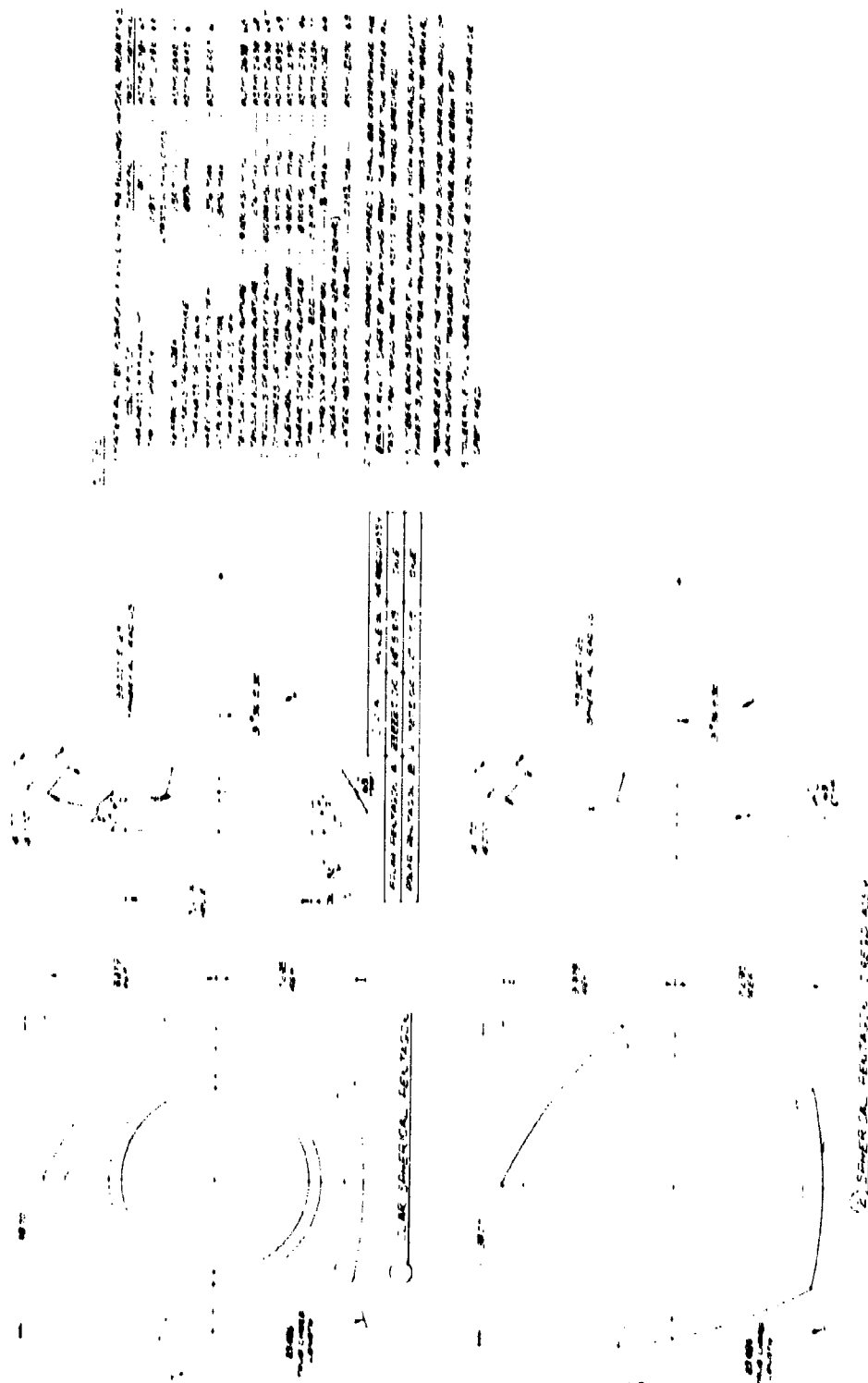


Figure 10A. Spherical pentagons for the 60-inch OD x 58-inch ID Model 2000 Nemo Hull.

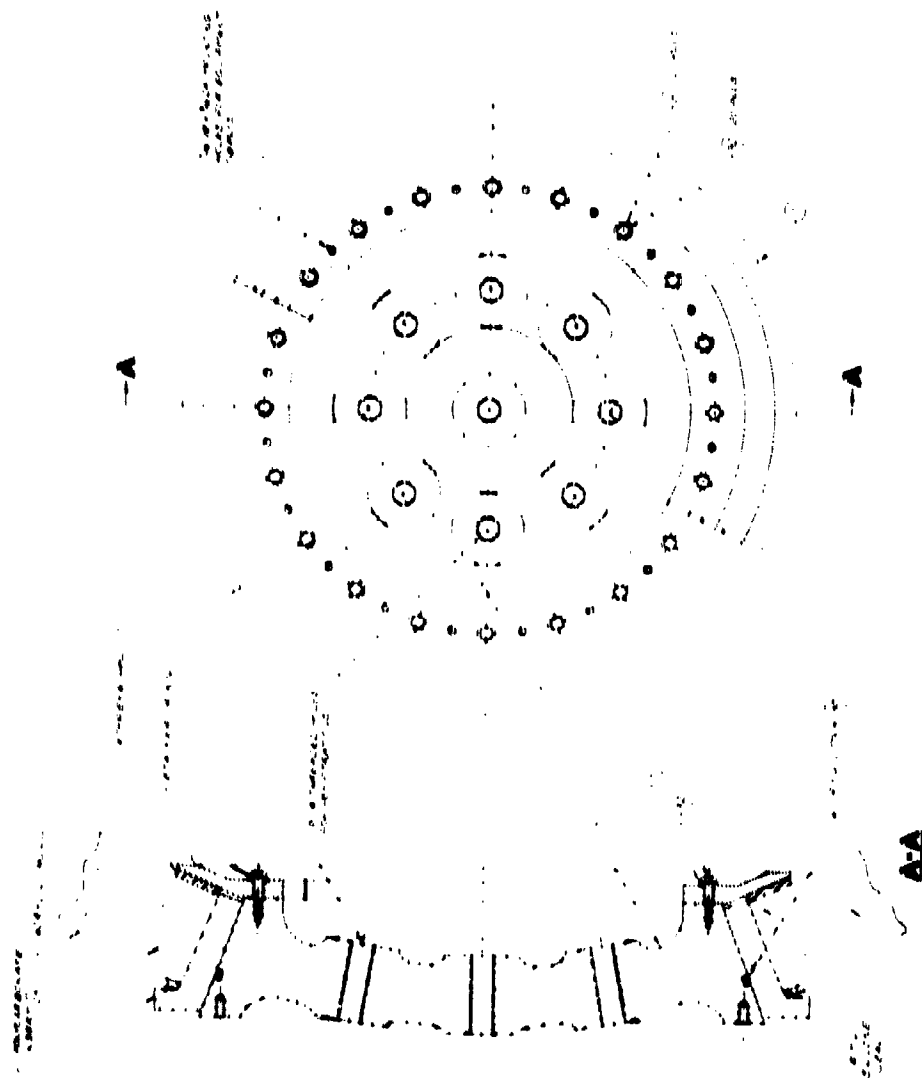


Figure 11A. Bottom plate assembly for the 60-inch OD x 58-inch ID Model 2000 Nemo Hull.

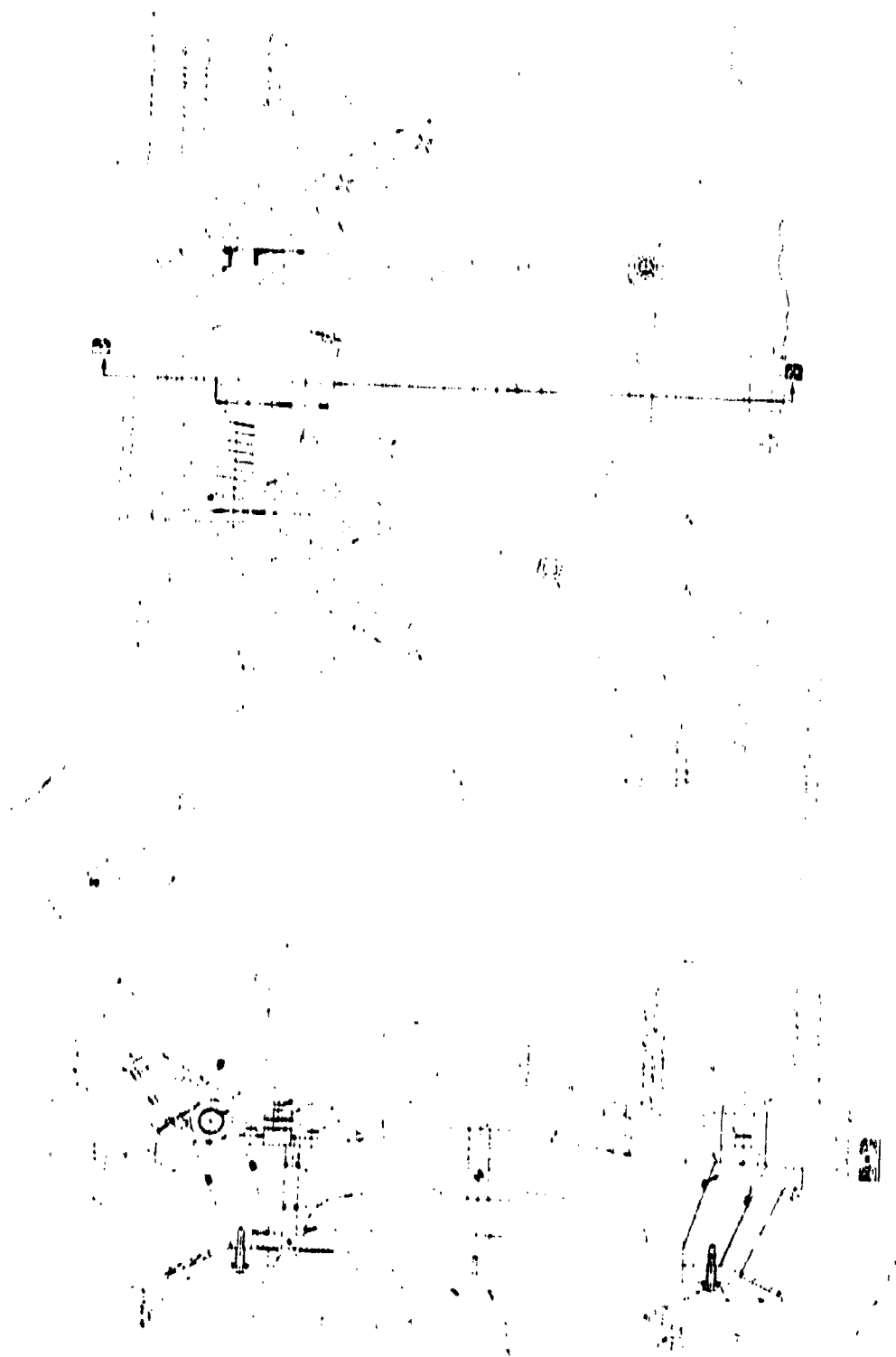


Figure 12A. Hatch assembly for the 66-inch OD x 58-inch ID Model 2000 Nemo Hull.

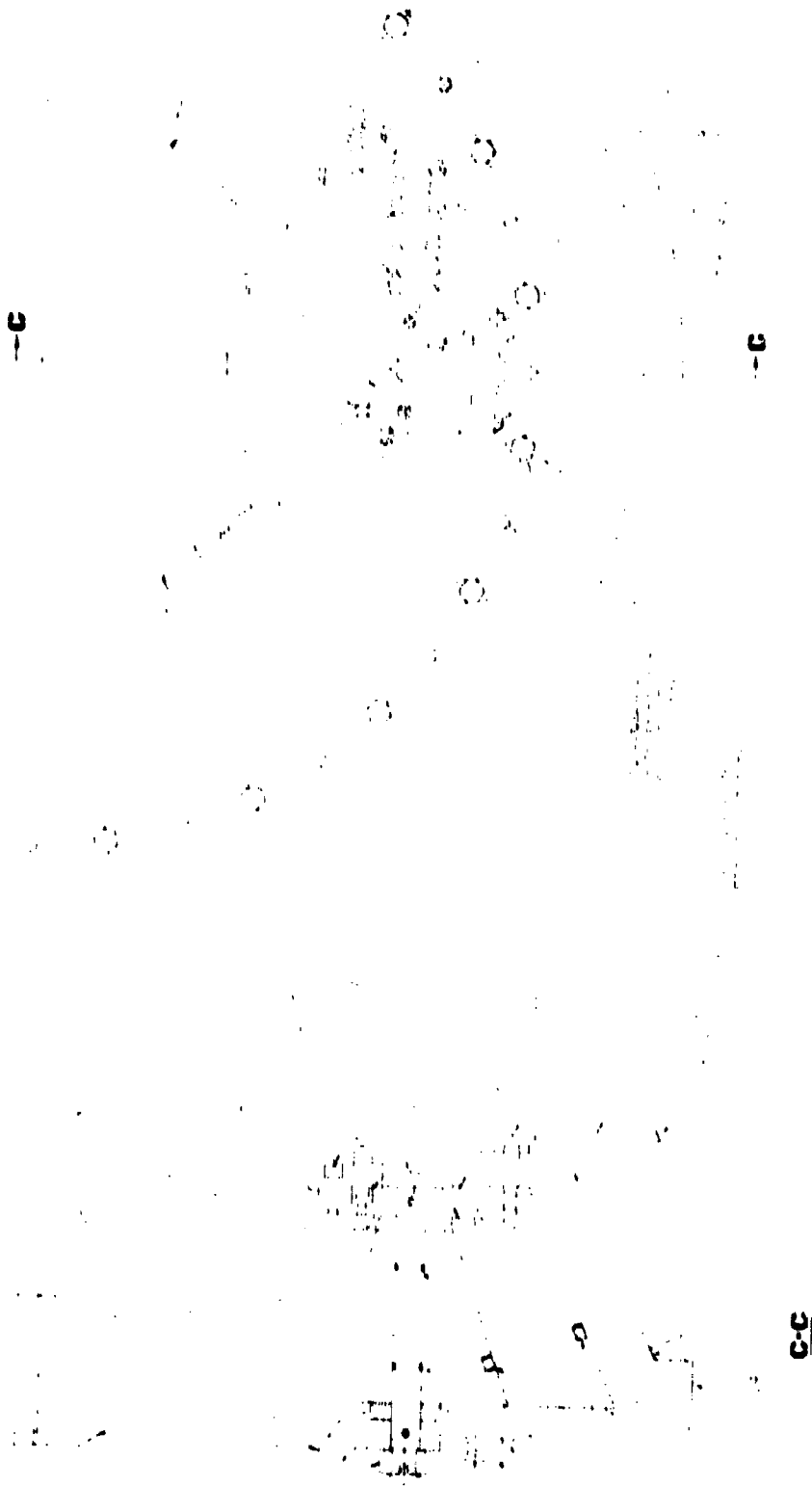


Figure 13A. Hatch back assembly for the 66-inch OD - 58-inch ID Model 2000 Nemo Hull.

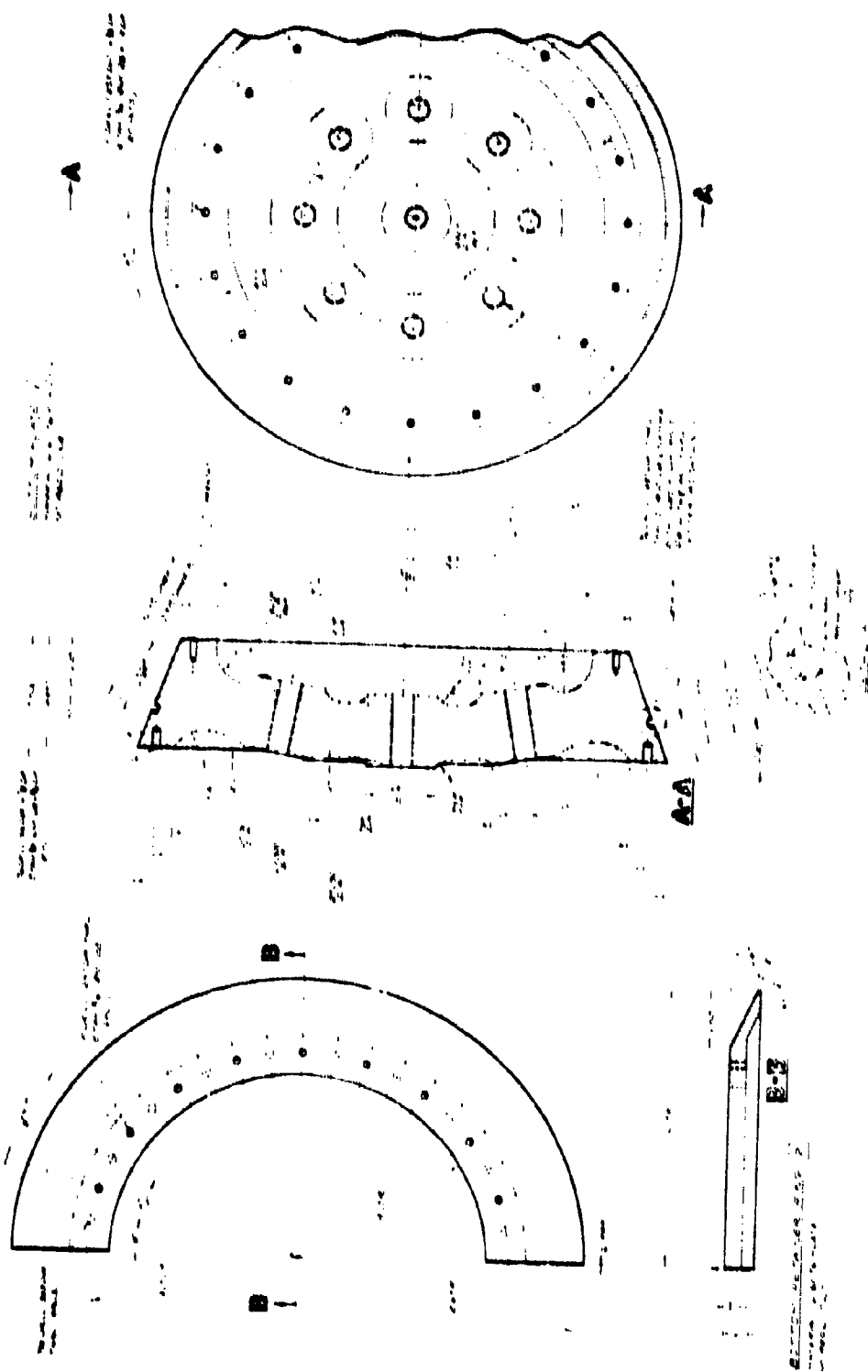


Figure 14A. Bottom plate and bottom refamer ring for the 60-inch OD x 58-inch ID Model 2000 Nemo Hull.

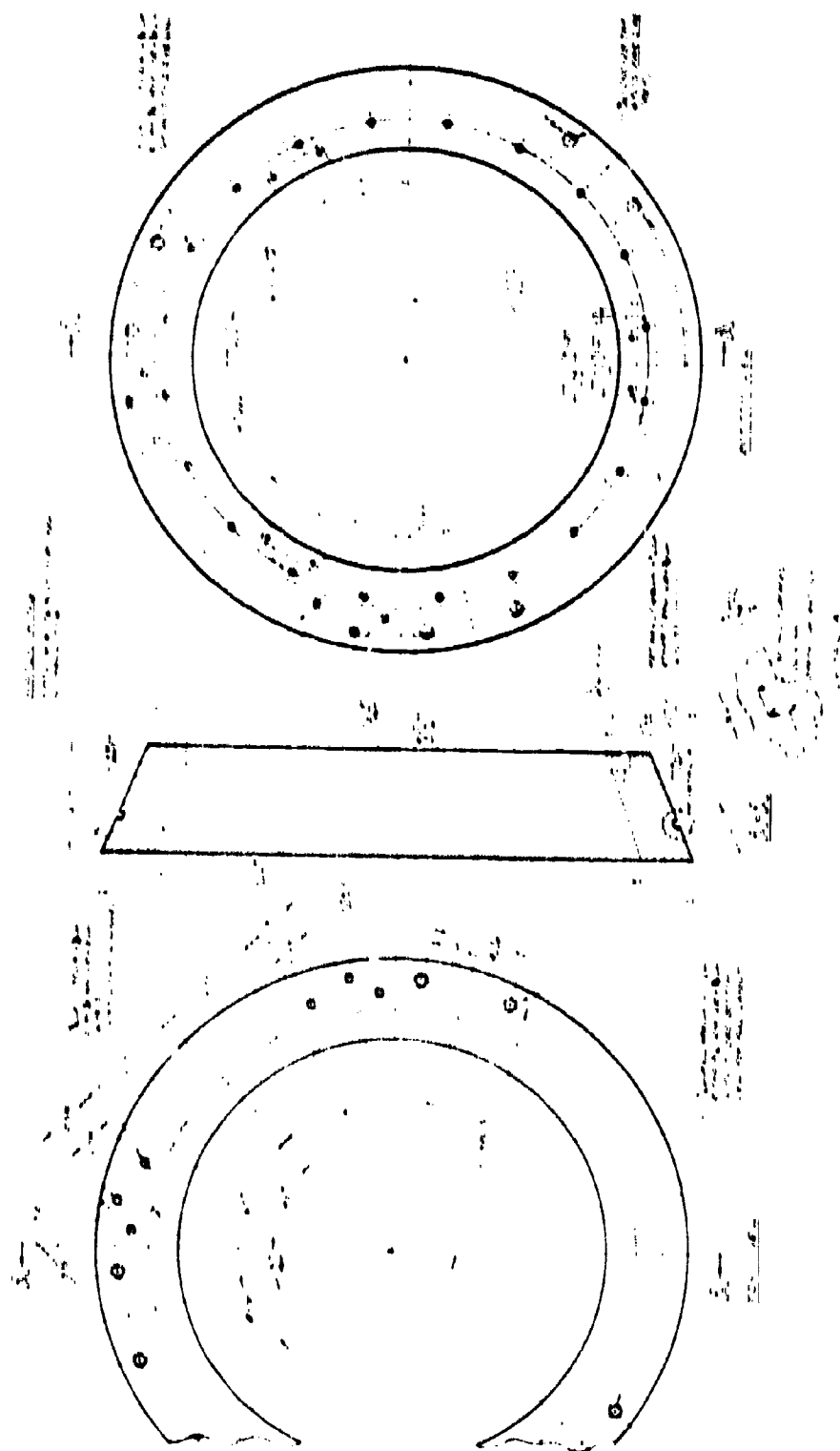


Figure 15A. Hatch ring for the 60-inch OD x 58-inch ID Model 2000 Nemo Hull.

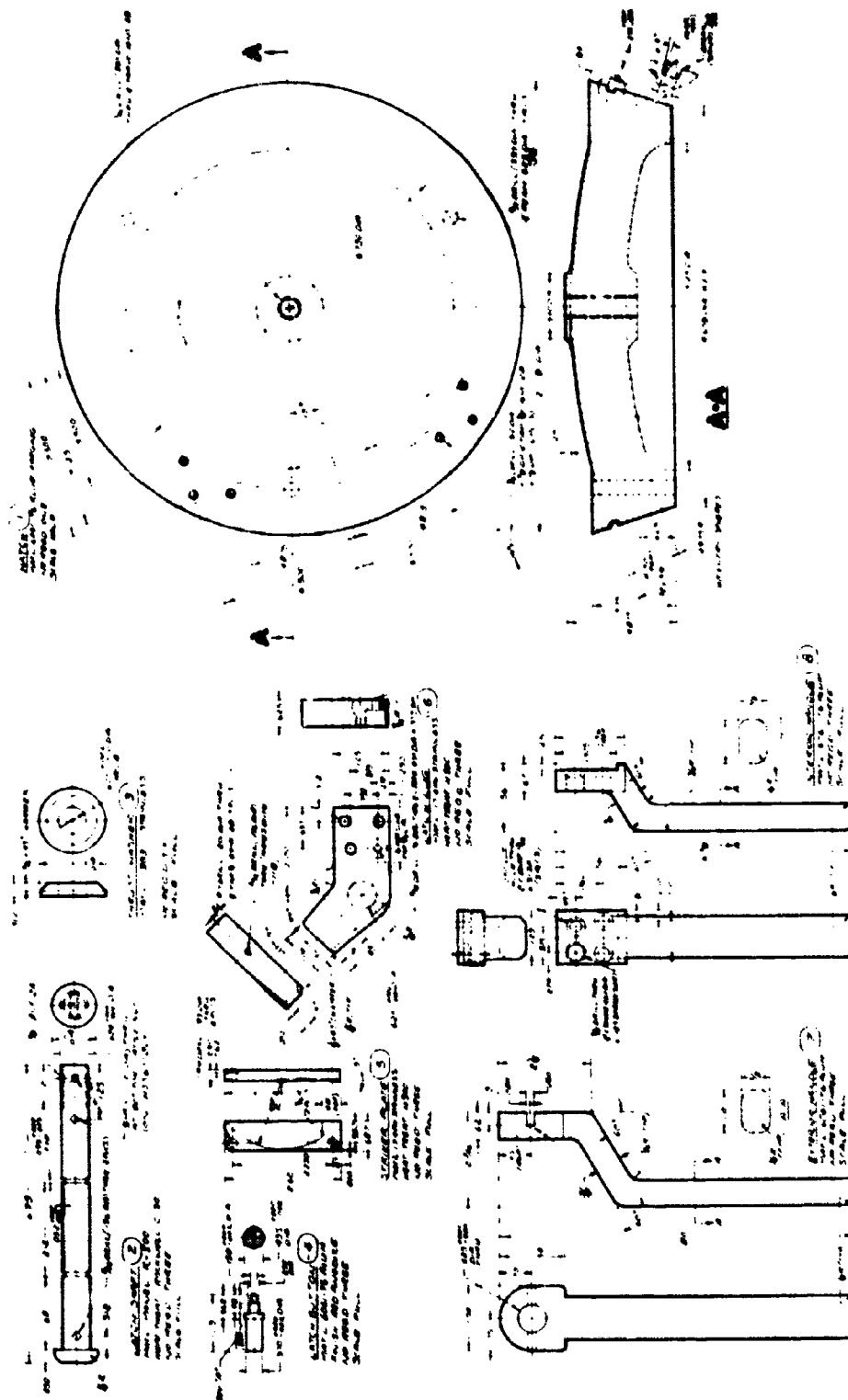


Figure 16A. Hatch and locking mechanism for the 60-inch OD x 58-inch ID Model 2000 Nemo Hull.

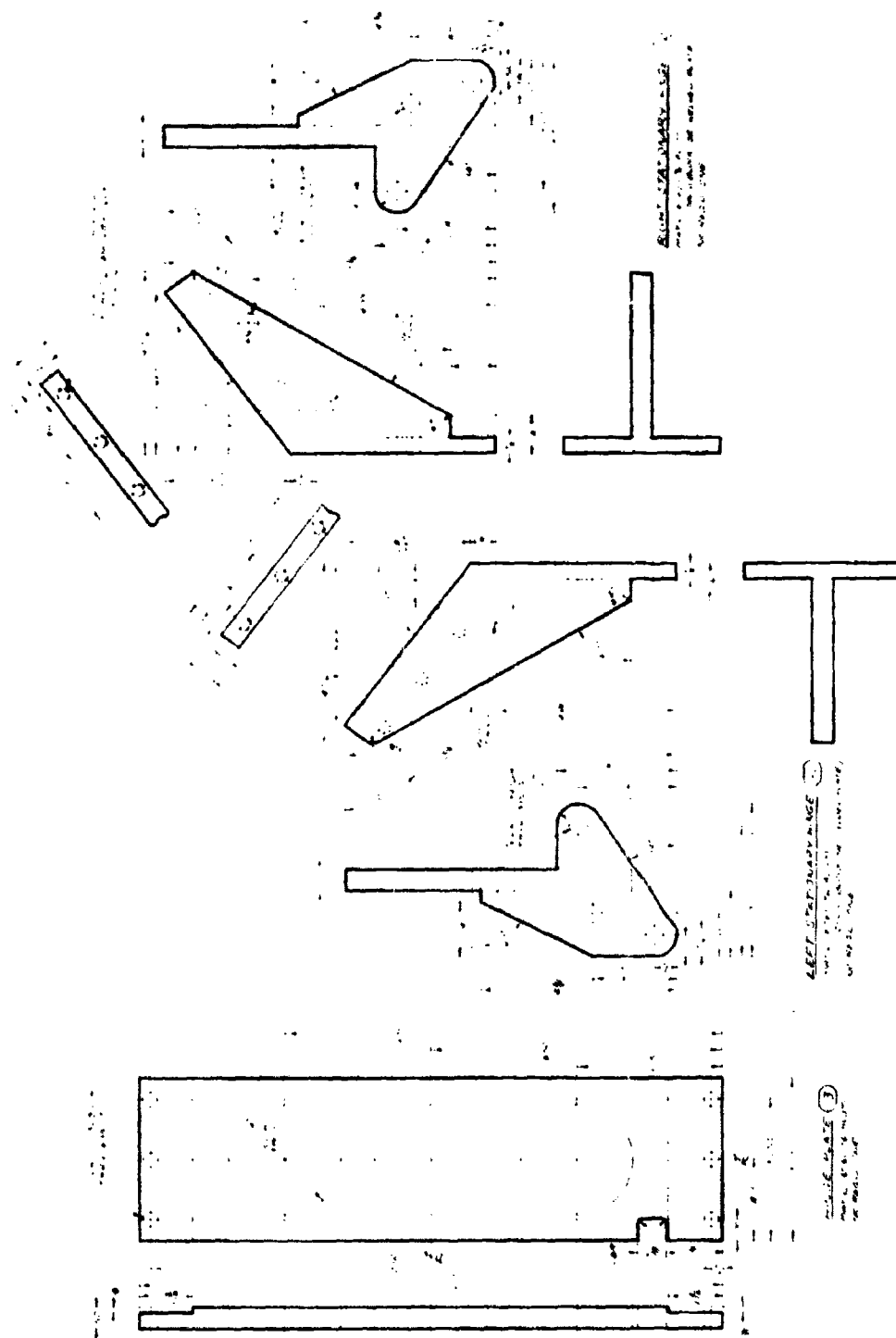


Figure 17A. Stationary hinges and hinge plate for the 66-inch OD x 58-inch ID Model 2000 Nemo Hull.

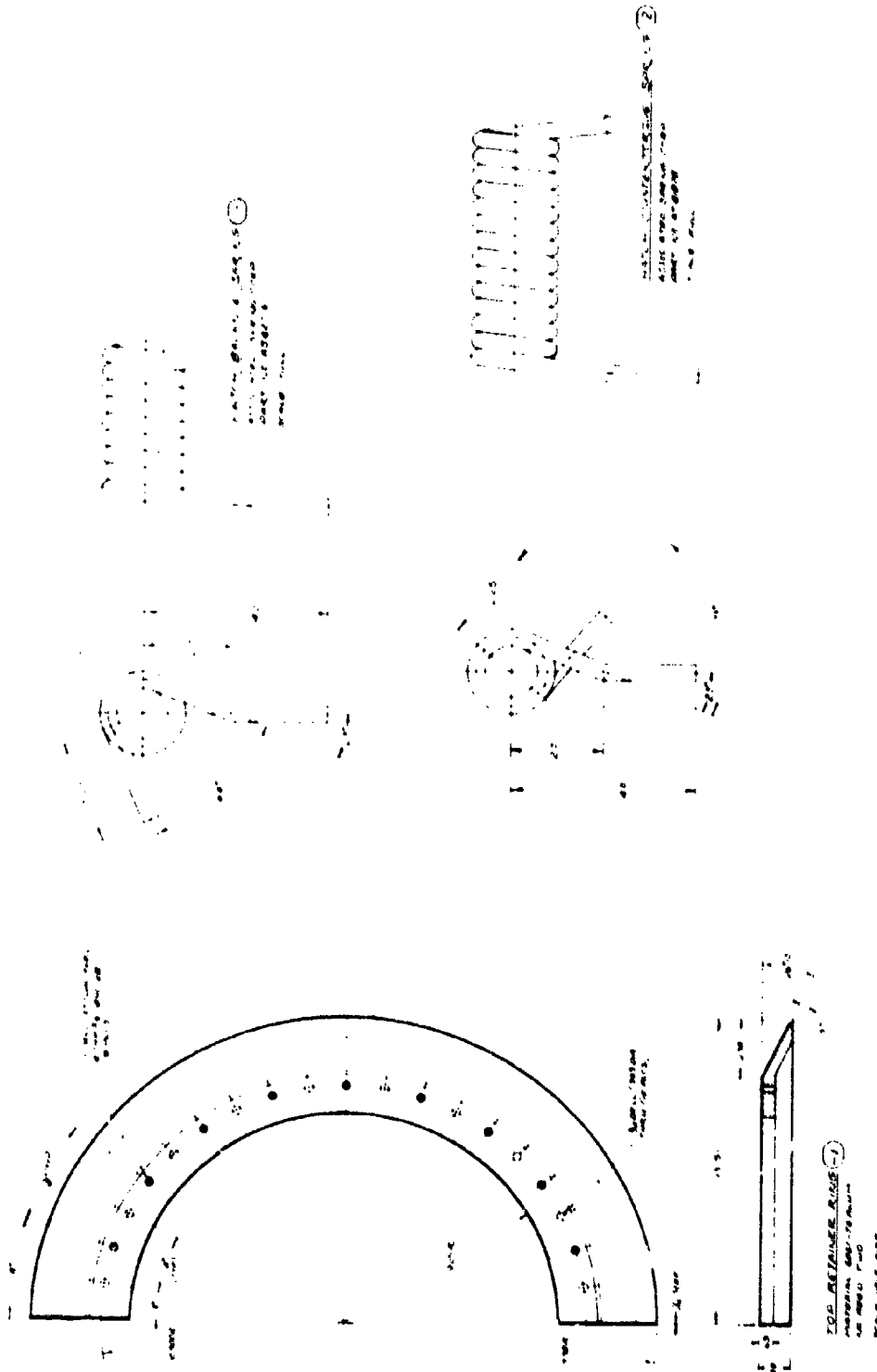


Figure 19A. Top retainer ring and counter balance springs for the 66-inch OD x 58-inch ID Model 2000 Nemo Hull.

APPENDIX B. FABRICATION OF 66-INCH OD X 58-INCH ID MODEL 2000 NEMO HULL

The 66-inch OD X 58-inch ID Model 2000 Nemo Hull assembly was fabricated basically in the same manner as the first 66-inch OD X 51-inch ID Model 600 Nemo Hull assembly built in 1968 by the Technical Services of Pacific Missile Range, Point Mugu, California. The cardinal features of that fabrication process are (1) cutting of discs from flat acrylic stock (Figure 1B), (2) thermofforming these discs into spherical sectors by means of metallic vacuum mold (Figure 2B), (3) cutting of spherical sectors into spherical pentagons (Figure 3B), (4) bonding of 12 spherical pentagons into a spherical shell (Figure 4B), (5) machining of metallic inserts in the form of top hatch and bottom penetration plate (Figure 5B), and placement of those inserts into polar hull openings (Figure 6B).

One phase of the fabrication process that has given trouble over the years to Nemo fabricators is that of the bonding of assembled 12 spherical pentagons. The problems associated with this phase of fabrication stem from the fact that the thickness of spherical pentagons bordering on a joint is not the same and that the width of joints between pentagons is not uniform. Because of the nonconformity in pentagon thickness and joint width it was difficult to seal the joint effectively so that it would contain the selfpolymerizing adhesive without leakage and yet assure a free flow of adhesive downwards and of displaced air upwards.

Steps were taken during fabrication of the Model 2000 Nemo Hull to eliminate the problems posed by nonuniform pentagon thicknesses and joint widths. These steps consisted of the following operations:

1. machining of all formed spherical sectors to uniform thickness in a lathe,
2. use of 0.125-inch thick x 0.25-inch diameter acrylic discs as spacers between individual pentagons during final assembly,
3. bonding of acrylic plastic strips to edges of joints for forming of pressure tight joint,
4. placement under pressure of selfpolymerizing adhesive into the joint cavities,

Because of these additional fabrication processing operations the resulting acrylic sphere is more uniform in thickness, sphericity, and diameter. As a result of this uniformity, the finished acrylic hull can be rated to higher operational pressure than was feasibly able prior to this time. Because the improved fabrication process may be of interest to others, a verbatim reproduction of shop fabrication instructions is attached as enclosure 1B at the end of this Appendix.

In parallel with the fabrication of the Model 2000 Nemo Hull, stringent quality control measures were adapted to assure a quality product and are attached as enclosures 2B through 9B. The quality control measures consisted of:

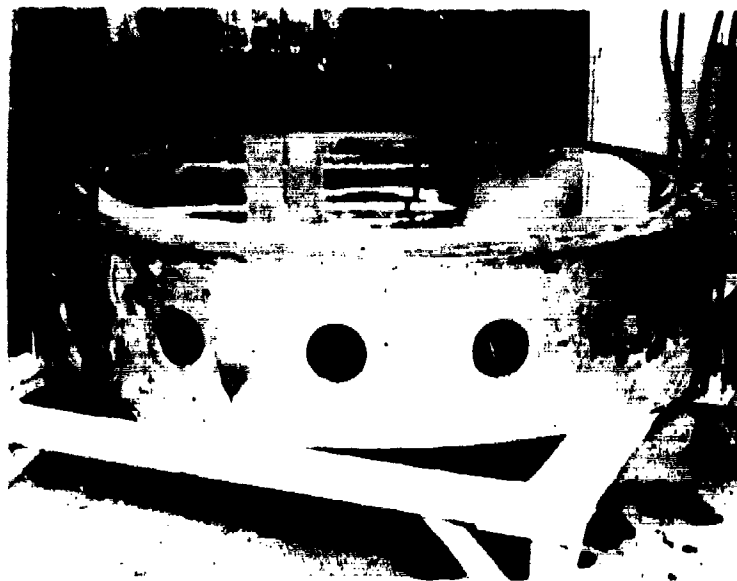
1. performing destructive tests on material coupons cut from each sheet of acrylic plastic to ascertain the material properties of plastic (enclosure 2B).

2. performing destructive tests on bonded material coupons to ascertain strength of bonded joints (enclosure 3B).

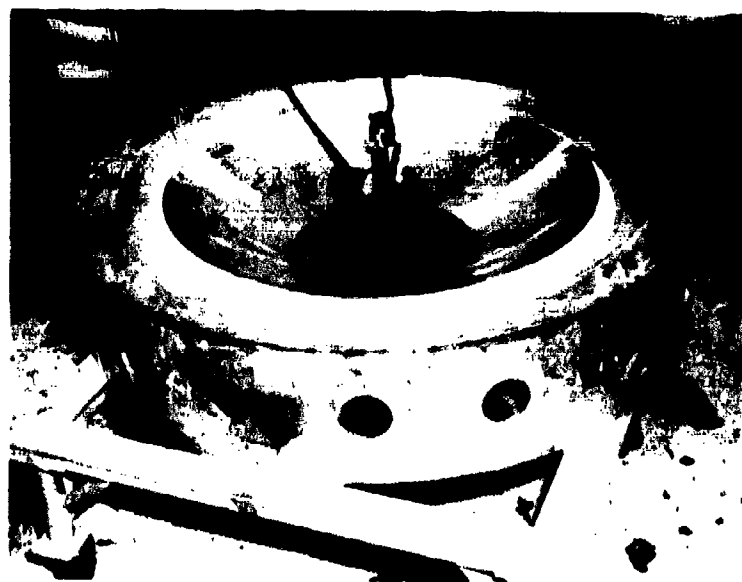
3. performing dimensional checks on the spherical hull to ascertain its adherence to specified dimensional tolerances. Samples of dimensional checks are shown for thickness of discs before annealing (enclosure 4B), thickness of disc after annealing (enclosure 5B), thickness of disc after forming (enclosure 6B), sphericity of disc after forming (enclosure 7B), thickness of spherical pentagon after machining (enclosure 8B) and diameter of bonded sphere after annealing (enclosure 9B).



Figure 1B. Sawing of flat plates into circular discs of 46-inch diameter.

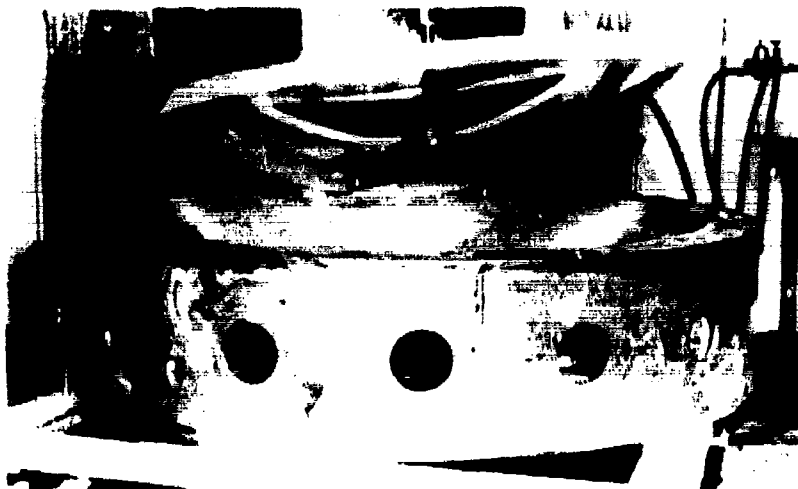


(a) Placement of disc into an aluminum female mold



(b) After forming the spherical sector is ready for removal from the mold

Figure 2B. Thermoforming of ^{238}Pu circular discs into spherical sectors.



(c) The sector is picked up with a vacuum suction disc from the mold



(d) Checking of sphericity on the formed sector

Figure 2B. (Continued).



Figure 3B. Sawing the spherical sector into the form of a spherical pentagon.



(a) Bonding of six pentagons to form a hemisphere



(b) Bonding of two hemispheres to form a sphere

Figure 4B. Holding fixture for bonding of spherical pentagons: note the large vacuum suction discs for holding of individual pentagons.



(c) Completed sphere after removal from bonding fixture

Figure 4B. (Continued).

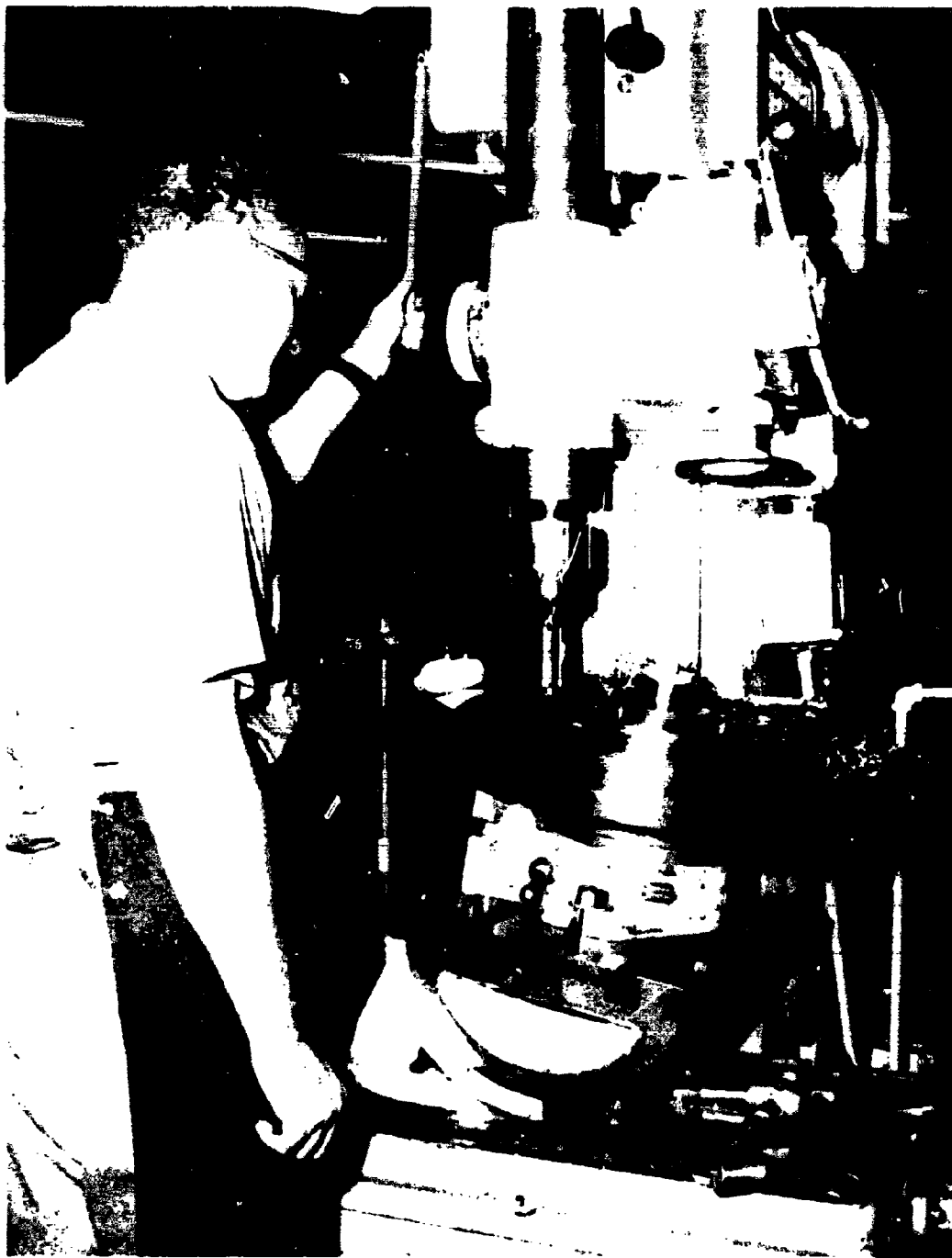


Figure 5B. Machining of metallic inserts for polar openings in the hull.

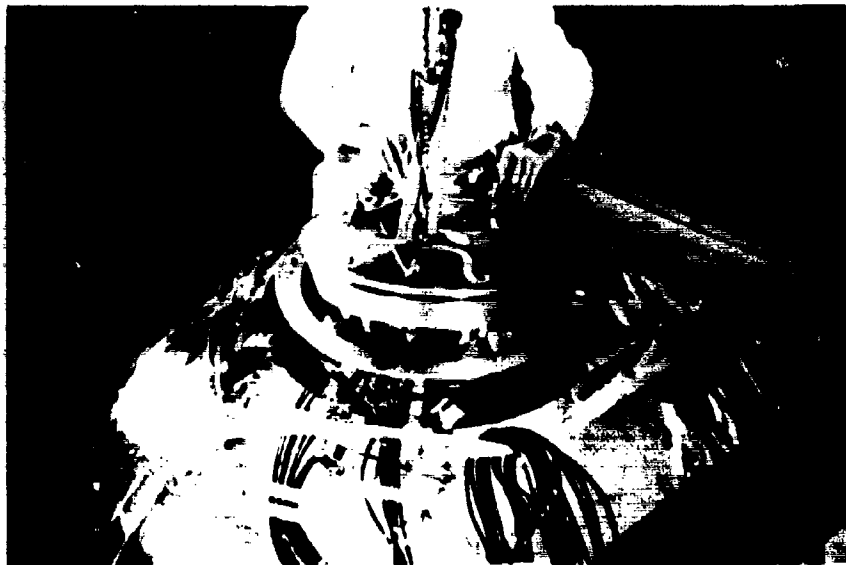


(a) Hatch seat being lowered in place

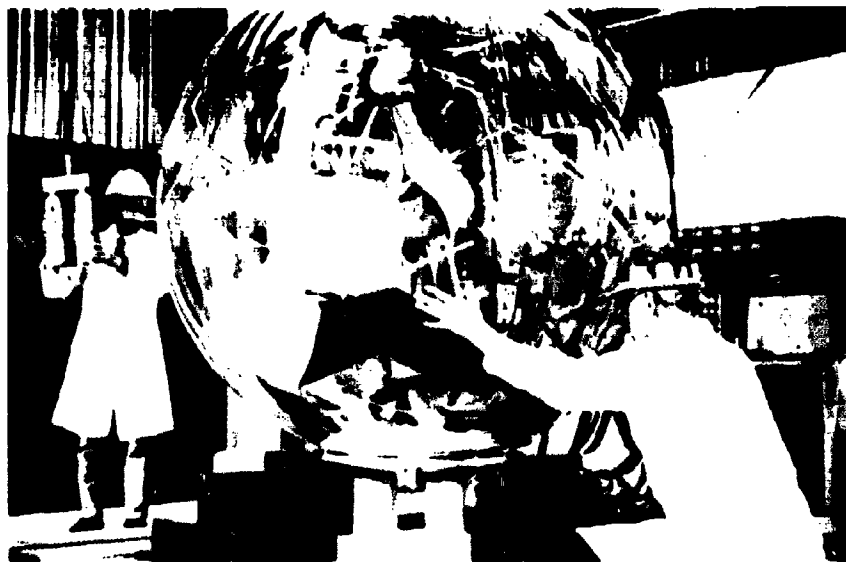


(b) Placement and bolting in place of hatch seat retaining flange

Figure 6B. Placement of metallic inserts into polar opening.



(c) Hatch assembly being attached to the hatch seat

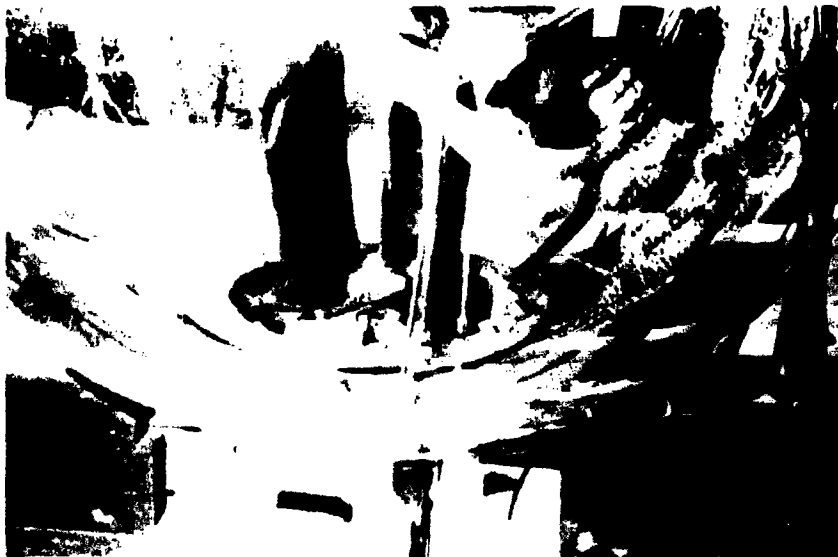


(d) The hull being lowered onto the bottom penetration plate

Figure 6B. (Continued).



(e) Placement in place of retaining flange for bottom penetration plate



(f) Bolting of retaining flange for bottom penetration plate

Figure 6B. (Continued).

ENCLOSURE 1B

SWEDLOW'S INSTRUCTIONS FOR WORKERS FABRICATING NEMO MOD 2000

1. Measure thickness of acrylic plate and chart at 12" intervals. Lay out a 46" diameter circle at the thickest part of the blank. Lay out nothing under 4.050 inches. Scribe SWU # on one cut off.
2. Bandsaw trim to line. Save one cut off that is scribed and send to C. Miller in Testing Lab.
3. Anneal the part at 325° F for 12 hours on a flat aluminum plate.
4. Inspect for thickness and chart at 12" intervals. Do not form plates under 4.170 inches.
5. Form per Forming Process Specification
6. Inspect for thickness (4.0 - 4.1) and contour.
7. Anneal @ 175° F for 24 hours.
8. Place part in machining fixture and align to marks. Drill three each 1/2" dia. holes and counterbore for 1/2" dia. Allen bolt. Bolt part down in three places.
9. Set up part and tracer template in Lucas lathe. Machine inside surface. Remaining thickness to be 4.050 minimum. Check contour readings to be sure part is 4.010 minimum at out of contour places. Part should be machined to 4.100 wherever possible and center section of part should not be cut as it will be under 4.100 thickness. Blend cut and uncut surfaces together with 360 grit wet sandpaper. This part must be polished to an optical finish after machining so the cut must be as smooth as possible.
10. Using vacuum lift place part in pentagon machine fixture and even up the edge of the part to the size of the fixture. Vacuum part into place on machining fixture. Make sure that hole in part comes out in the center of the piece to be cut off. Close air toggle clamps. Start saw and set feed at 25 inches per minute.
11. While cutting off first piece the saw may have a tendency to slow down or stop. If this happens, immediately press the return button, let the saw return and start the cut over. After cutting off the first piece, open

up the air toggle clamps and press the lever all the way to the left. This will lift the rotating part of the fixture slightly so that the index pin can be pulled and the part rotated to the next position. Continue this procedure until all five cuts have been made. Attach polar hole machining fixture to rotary table and place table on the milling machine. Two pentagons only. Place pentagon into machining fixture and bolt into place. Using a 7/8" dia. x 5" long end mill, cut a hole thru the part per the dimensions on NEMO Model 2000 Drawing #2003

12. Inspect for blueprint dimensions.
13. Anneal at 175°F for 24 hours.
14. Clean up.
15. Take to assembly room.
16. Place one (1) Polar Pentagon in center of assembly fixture and using the large Starrett No. 656-441 indicator attached to extension, set against 1/2" ball situated in center of assembly pad.
17. Making sure indicator is laying flat against holding pad and measure distance from 1/2" ball to the inside of cut out in pentagon.
18. When pentagon is centered, place "L" shaped clamps to hold pentagon in place and bolt tightly to keep pentagon from moving during assembly.
19. Obtain 1/8" thick x 1/4" diameter acrylic spacers and bond approximately 4" from each corner centered.
NOTE: Two (2) spacers are needed per side only. If one pentagon has these blocks, then omit blocks to mating side.
Use PS-30 cement - for bonding spacers.
20. Using the vacuum hand lift, place five (5) pentagons into assembly fixture and align with polar pentagon.
21. After alignment obtain large micrometer with Brown and Sharpe No. 8241-941 dial indicator from inspection box. Obtain the three rods from box (1) 22" (2) 23" and (3) 21". Assemble together and set dial indicator to read zero.

NOTE: Dial indicator will not set at zero-zero dial, but will set at 600,
so turn dial indicator to read zero to 600.

22. Using dial indicator measure the diameter of the hemisphere and shim where necessary to read $66" \pm .25"$. Measure hemisphere.

NOTE: Each pentagon must be measured to one situated directly across from
from one to the other.

23. When hemisphere is within spherical tolerance of $66" \pm .250"$, obtain Flex G acrylic strips $3/4"$ thick or S310 material $0.750"$ wide by $36"$ long. Take to Machining and rout a groove down the center length $1/8"$ wide x $1/2"$ deep.
24. Form these strips to fit both outside and inside surfaces of set pentagons. Using methylene chloride, bond the strips to the pentagons.
25. After all strips have been bonded to hemisphere, place a bead of PS-18 resin around all strips to prevent leaks after hemisphere has been filled with S-49 casting cement.
26. Drill an "F" size hole at lowest point of hemisphere. Place a $1/4"$ OD aluminum tube $3"$ long into hole and cement into place between pentagons.
27. Obtain 2000 grams of basic S-49 resin from resin mixing room-in-a new, clean gallon can: Mix 4 grams of benzoin (.2) and 10 grams of lauric peroxide (.5). Place lid on container. Take resin to the NEMO room which is a temperature controlled room @ a constant 72°F .
28. Place gallon can on converted edge attachment sander, and set atop the two (2) rollers. Turn switch on and let roll over night.
29. Place mixed S-49 as resin into pressure pot and attach nitrogen bottle to pot. Attach fill tube from pot to $1/4"$ OD Aluminum tube on sphere.
30. Apply five (5) pounds pressure.
31. Fill joints all around Polar Pentagon and allow resin to rise approximately one (1) inch above the upright joints. (This allows for shrinkage).
32. Clamp off tube.
33. Allow to cure in NEMO room until hard (approximately 24 hours). Room is

to be kept between 70°F and 75°F temperature.

34. Remove first hemisphere from cement fixture.
35. Rout joints on both outside and inside flush with pentagons.
36. Polish up all seams on both inner and outer surfaces.
37. Place six (6) new pentagons into assembly fixture and assemble same as first pentagon. Follow steps one (1) through twenty-two (22) above.
38. Place hemisphere Number one (1) on top of Number two (2) and check spherical diameter.
39. If hemispheres measure within tolerance of $66" \pm .250"$, cut, fit and cement joint strips around equator of sphere leaving a funnel at the top of each bottom pentagon.
40. In obtaining and preparing S-49 resin, repeat Steps 27 and 28
41. To feed S-49 resin into the equator section of sphere, follow Steps 29 and 30 of Operation 5.
42. Allow resin to cure in NEMO room until hard (approximately 24 hours). Room is to be kept between 70°F and 75°F temperature.
43. Remove sphere from assembly fixture. Using the cell casting hoist, hook up lifting plate to hoist, fold lifting plate and insert into sphere. Making sure lifting plate will not damage sphere, lift sphere from fixture.
44. Machine, sand and polish all bonded areas.
45. Anneal sphere in a 175°F oven for 24 hours.
46. Inspect all cemented joints for voids larger than 1/4" in diameter.
47. Final clean up.
48. Final Inspection.
49. Wrap with Protec 10V.

ENCLOSURE 2B

SWEDLOW, INC.

Reference: 45-74-121

Date: March 18, 1974

TEST REPORT

CUSTOMER: Disbursing Officer, DCASR, Los Angeles
11099 So. La Cienega Boulevard
Los Angeles, California 90045

PURCHASE ORDER NO.: N00123-73-C-1671

MATERIAL TESTED: Remnants from each sheet used in fabrication
of NEMO Model 2000 Hull


Test specimens were cut to rough dimensions using a bandsaw and to final dimensions (with the exception of tensile specimens) by means of a vertical mill, with a six-flute, carbide-tipped shell end-mill. Tensile specimens were routed to the configuration of a template which complies with dimensions set forth in A.S.T.M. D-638 for Type I specimens. Sharp edges were broken to about .005 inch. Machined surfaces were sanded, first with 280 grit paper, and finally with 600 grit Wet-or-Dry paper to remove tool marks. All specimens were annealed to remove any residual stresses introduced during machining.

Test specimens were conditioned, at a temperature of $73.5 \pm 2^\circ\text{F}$ and relative humidity of $50 \pm 5\%$, for a period of 40 hours prior to testing.

Tensile, compressive and flexural values were obtained by means of a Tinius-Olsen Elect-O matic Testing Machine. Deformation under load values were obtained on a Tinius-Olsen tester designed for that particular test.

Respectfully submitted,

SWEDLOW, INC.


C. A. Miller, Supervisor
Physical Testing Laboratory



SWEDLOW, INC.

TEST REPORT

Date: March 18, 1974

Purchase Order No.: N00123-73-C-1671

FOR: NEMO Model 2000 Hull

Sales Order No.: 3-5940

Page 1

TENSILE: Conditioned 40 hours at 73°F and 50 Percent R. H.

ASTM D-638 tested at 0.05 In/Min

<u>SHEET NO.</u>	<u>SPECIMEN SIZE (INCH)</u>	<u>LOAD (LBS)</u>	<u>ULTIMATE (PSI)</u>	<u>ELONGATION (PERCENT)</u>	<u>MODULUS (PSI)</u>
021	1- .236 x .483	1330	11,668	7.0	447,000
	2- .242 x .478	1365	11,800	6.0	465,000
023	1- .247 x .481	1465	12,331	6.0	467,000
	2- .251 x .476	1360	11,382	6.0	437,000
024	1- .255 x .479	1400	11,461	5.5	437,000
	2- .254 x .482	1420	11,600	5.5	485,000
025	1- .253 x .481	1425	11,709	5.5	473,000
	2- .252 x .479	1420	11,764	5.0	490,000
026	1- .251 x .483	1415	11,671	5.5	474,000
	2- .252 x .481	1355	11,179	5.5	456,000
027	1- .252 x .479	1315	10,893	5.5	446,000
	2- .253 x .477	1275	10,565	5.5	495,000
028	1- .248 x .472	1235	10,551	5.0	498,000
	2- .252 x .474	1270	10,632	5.5	492,000
029	1- .253 x .471	1200	10,070	4.0	446,000
	2- .247 x .474	1185	10,121	4.0	449,000
034	1- .254 x .475	1290	10,692	5.5	475,000
	2- .247 x .475	1265	10,781	5.0	478,000
035	1- .250 x .479	1250	10,440	5.0	505,000
	2- .246 x .477	1120	9,545	3.0	428,000
036	1- .250 x .476	1280	10,756	5.5	454,000
	2- .251 x .477	1275	10,649	5.0	465,000
037	1- .249 x .475	1250	10,570	5.5	465,000
	2- .248 x .474	1235	10,504	5.5	447,000

TESTED BY: J. E. H. (J. E. H.)



NEMO Model 2000 Hu11
S. O. No. 3-5940
Test Report, Continued
Page 2

FLEXURAL - Conditioned 40 Hours at 73°F and 50 Percent R. H.

ASTM D-790 - 4 inch span, test speed 0.11 In/Min

<u>SHEET NO.</u>	<u>SPECIMEN SIZE (INCH)</u>	<u>LOAD (LBS)</u>	<u>ULTIMATE (PSI)</u>	<u>MODULUS (PSI)</u>
021	1- .500 x .258	95.8	17,261	415,000
	2- .500 x .258	95.5	17,207	443,000
023	1- .498 x .258	101.3	18,326	444,000
	2- .491 x .257	82.3	15,238	442,000
024	1- .500 x .258	103.1	18,577	452,000
	2- .494 x .258	101.3	18,474	457,000
025	1- .501 x .257	102.0	18,508	433,000
	2- .502 x .258	103.1	18,503	445,000
026	1- .501 x .258	101.1	18,180	460,000
	2- .498 x .257	101.3	18,492	463,000
027	1- .493 x .256	96.3	17,883	459,000
	2- .495 x .256	98.0	18,127	477,000
028	1- .493 x .249	93.1	18,258	478,000
	2- .493 x .247	93.7	18,686	474,000
029	1- .494 x .246	92.4	18,048	479,000
	2- .495 x .249	93.6	18,306	475,000
034	1- .492 x .247	88.1	17,588	475,000
	2- .493 x .246	82.5	16,624	480,000
035	1- .495 x .248	78.7	15,511	487,000
	2- .494 x .247	90.6	18,047	484,000
036	1- .494 x .247	77.0	15,326	473,000
	2- .493 x .248	92.1	18,210	484,000
037	1- .492 x .248	91.4	18,113	469,000
	2- .495 x .248	92.2	18,194	467,000

SWEDLOW, INC. 1001 E. 10TH ST. ST. LOUIS, MO. 63102



NEMO Model 2000 Hull
S. O. No. 3-5940
Test Report, Continued
Page 3

DEFORMATION UNDER LOAD

ASTM D 621 - Tested as received at 122°F for 24 hours under 4000 psi load
Test Specimens: 1/2 Inch Cube

SHEET NO.	DEFORMATION (INCH)		DIFFER (IN)	MICROMETER READING (IN)	CALC. ORIG. THICKNESS (IN)	DEFORM. (%)
	10 SEC.	24 HOURS				
021	1- 0.0863	0.0889	0.0026	0.4998	0.5024	0.52
	2- 0.0822	0.0848	0.0026	0.5025	0.5051	0.51
023	1- 0.0857	0.0886	0.0029	0.4985	0.5014	0.58
	2- 0.0813	0.0842	0.0029	0.5020	0.5049	0.57
024	1- 0.0819	0.0843	0.0024	0.5013	0.5037	0.48
	2- 0.0764	0.0788	0.0022	0.5025	0.5047	0.44
025	1- 0.0755	0.0778	0.0023	0.5036	0.5059	0.45
	2- 0.0763	0.0787	0.0024	0.5023	0.5047	0.48
026	1- 0.0765	0.0795	0.0030	0.5014	0.5044	0.60
	2- 0.0752	0.0774	0.0022	0.5007	0.5029	0.44
027	1- 0.0684	0.0708	0.0024	0.5029	0.5053	0.47
	2- 0.0676	0.0699	0.0023	0.5036	0.5039	0.46
028	1- 0.0733	0.0761	0.0023	0.4980	0.5003	0.46
	2- 0.0708	0.0735	0.0027	0.5003	0.5030	0.54
029	1- 0.0691	0.0712	0.0021	0.5014	0.5035	0.42
	2- 0.0707	0.0733	0.0026	0.4997	0.5023	0.52
034	1- 0.0709	0.0743	0.0034	0.4986	0.5020	0.67
	2- 0.0720	0.0751	0.0031	0.4983	0.5014	0.61
035	1- 0.0714	0.0745	0.0031	0.4990	0.5021	0.61
	2- 0.0711	0.0744	0.0033	0.4980	0.5013	0.65
036	1- 0.0715	0.0747	0.0032	0.4975	0.5007	0.63
	2- 0.0698	0.0734	0.0036	0.4996	0.5032	0.72
037	1- 0.0708	0.0740	0.0032	0.4991	0.5023	0.64
	2- 0.0707	0.0740	0.0033	0.4982	0.5015	0.66



NEMO Model 2000 Hull
S. O. No. 3-5940
Test Report, Continued
Page 4

SHEAR STRENGTH

ASTM D-732

Rate of Test: 0.05 In/Min
Punch Diameter: 0.999 In. (1.000 In. Dia. disc punched out)

<u>SHEET NO.</u>		<u>THICKNESS (INCH)</u>	<u>MAXIMUM LOAD (LBS)</u>	<u>SHEAR STRENGTH (PSI)</u>
021	1-	0.259	8,240	10,100
	2-	0.253	8,250	10,400
023	1-	0.255	8,190	10,200
	2-	0.254	8,220	10,300
024	1-	0.254	8,120	10,300
	2-	0.256	8,260	10,300
025	1-	0.257	8,220	10,200
	2-	0.258	8,340	10,300
026	1-	0.254	8,830	11,100
	2-	0.255	8,210	10,300
027	1-	0.250	7,800	9,930
	2-	0.245	7,770	10,100
028	1-	0.245	8,220	10,700
	2-	0.254	8,440	10,600
029	1-	0.250	8,200	10,400
	2-	0.253	8,690	10,900
034	1-	0.253	8,870	11,200
	2-	0.254	8,770	11,000
035	1-	0.252	9,130	11,500
	2-	0.253	8,450	10,600
036	1-	0.255	9,100	11,400
	2-	0.253	8,670	10,900
037	1-	0.254	8,340	10,500
	2-	0.256	7,950	9,880

NEMO Model 2000 Hull
 S. O. No. 3-5940
 Test Report, Continued
 Page 5

COMPRESSIVE PROPERTIES : Tested at Room Temperature

ASTM D-695 Rate of Test: 0.05 In/Min

<u>SHEET NO.</u>		<u>SPECIMEN SIZE (INCH)</u>	<u>YIELD LOAD (LBS)</u>	<u>YIELD STRENGTH (PSI)</u>	<u>MODULUS (PSI)</u>
021	1-	0.503 x 0.502 x 1.504	4,880	19,300	570,000
	2-	0.503 x 0.502 x 1.505	4,950	19,600	530,000
023	1-	0.500 x 0.503 x 1.502	4,630	18,400	520,000
	2-	0.501 x 0.503 x 1.502	4,590	18,200	500,000
024	1-	0.503 x 0.503 x 1.499	4,610	18,200	510,000
	2-	0.504 x 0.503 x 1.499	4,740	18,700	500,000
025	1-	0.505 x 0.505 x 1.502	4,660	18,300	510,000
	2-	0.504 x 0.504 x 1.500	4,780	18,800	510,000
026	1-	0.503 x 0.503 x 1.501	4,570	18,100	510,000
	2-	0.503 x 0.501 x 1.500	4,650	18,500	520,000
027	1-	0.504 x 0.506 x 1.502	4,650	18,200	510,000
	2-	0.506 x 0.504 x 1.504	4,690	18,400	520,000
028	1-	0.501 x 0.501 x 1.500	4,650	18,500	540,000
	2-	0.502 x 0.502 x 1.507	4,710	18,700	540,000
029	1-	0.502 x 0.502 x 1.506	4,810	19,100	530,000
	2-	0.502 x 0.502 x 1.506	4,610	18,300	500,000
034	1-	0.501 x 0.502 x 1.505	4,520	18,000	510,000
	2-	0.501 x 0.500 x 1.505	4,600	18,400	530,000
035	1-	0.502 x 0.501 x 1.506	4,650	18,500	520,000
	2-	0.503 x 0.503 x 1.506	4,480	17,700	530,000
036	1-	0.503 x 0.502 x 1.505	4,510	17,900	510,000
	2-	0.501 x 0.500 x 1.506	4,490	17,900	510,000
037	1-	0.501 x 0.502 x 1.505	4,640	18,400	530,000
	2-	0.503 x 0.502 x 1.503	4,510	17,900	530,000

ENCLOSURE 3B



SWEDLOW, INC.

Date: 21 May 1974

TEST REPORT

For: NEMO Model 2000 Hull

Purchase Order No. N00123-73-C-1671

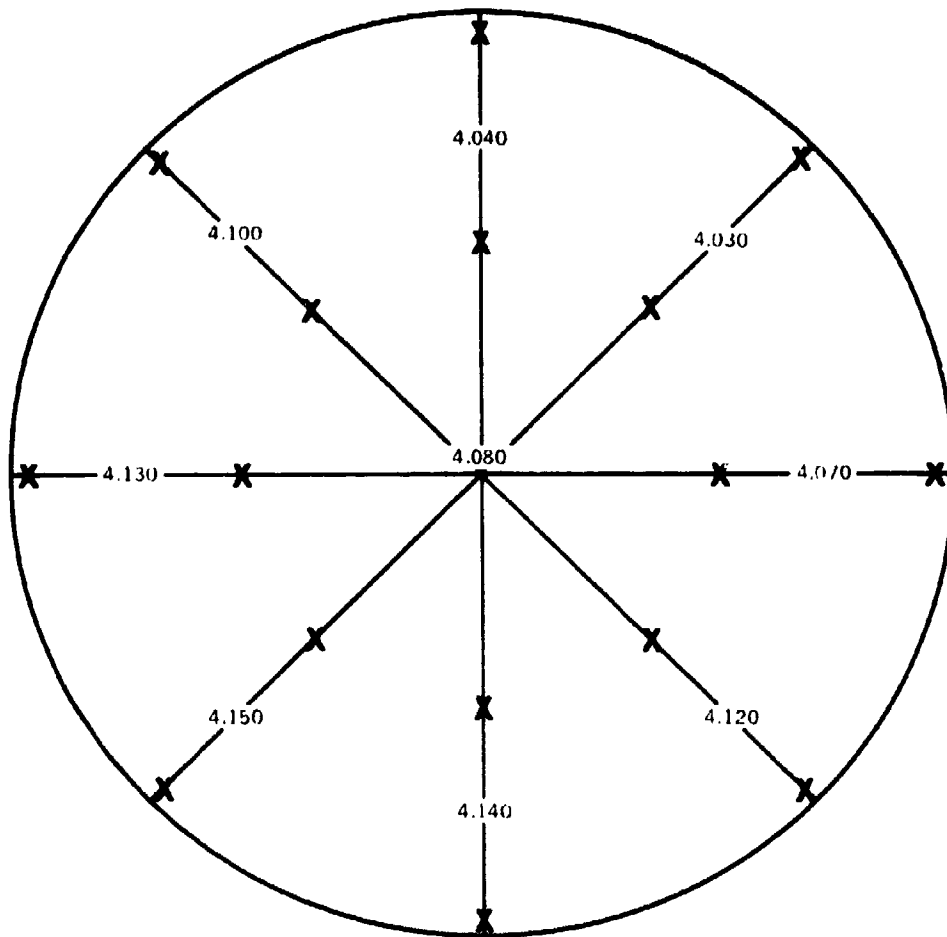
BONDED JOINT TENSILE STRENGTH

(Required : 5000 psi)

Test specimens were machined from the joint evaluation coupon which had been bonded and annealed in the same manner as the pressure hull. Specimens were of the dimensional configuration set forth in Sketch No. 2002. The testing speed used was 0.05 inch per minute.

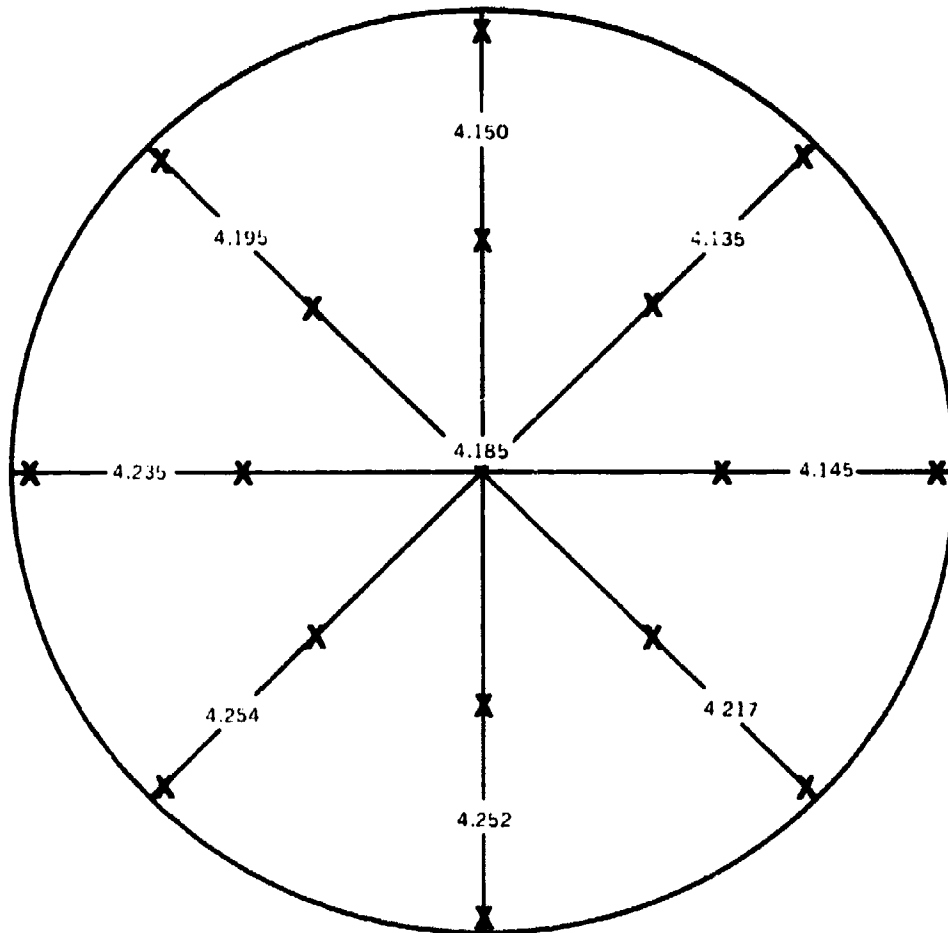
<u>Specimen</u>	<u>Width (In)</u>	<u>Thickness (In)</u>	<u>Load (Lbs)</u>	<u>Ultimate Strength (psi)</u>	<u>Mode of Failure</u>
1	0.744	0.529	3015	7661	Cohesive
2	0.747	0.532	3210	8074	Acrylic
3	0.750	0.485	2825	7766	Cohesive
4	0.746	0.547	3720	9116	Cohesive
5	0.750	0.540	2075	5123	Cohesive
6	0.749	0.534	3550	8876	Cohesive
7	0.747	0.531	2920	7362	Cohesive
8	0.748	0.526	3240	8235	Cohesive
9	0.742	0.519	2365	6141	Cohesive
10	0.748	0.536	3320	8281	Cohesive
11	0.745	0.536	3390	8489	Cohesive
12	0.744	0.534	3440	8659	Cohesive
Average				7815	

C. A. Miller, Supervisor
Testing Laboratory

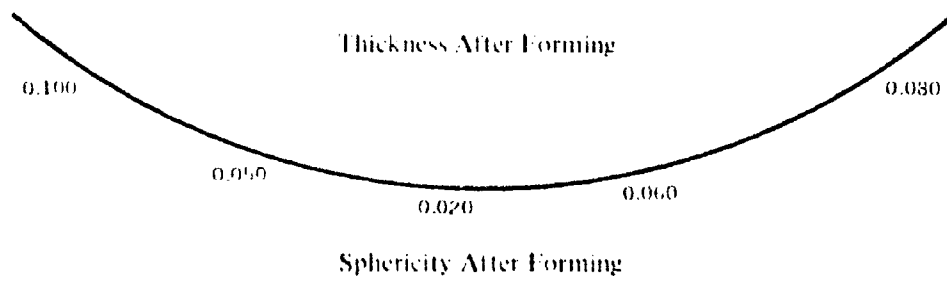
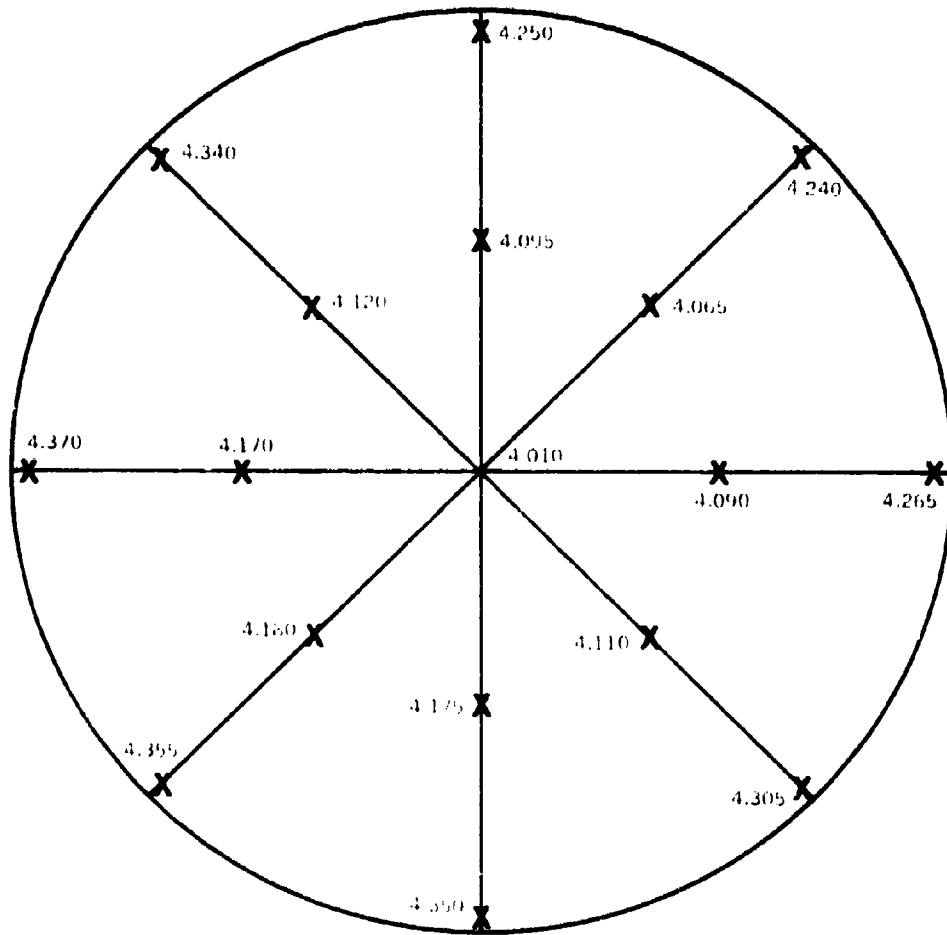


Thickness Before Annealing

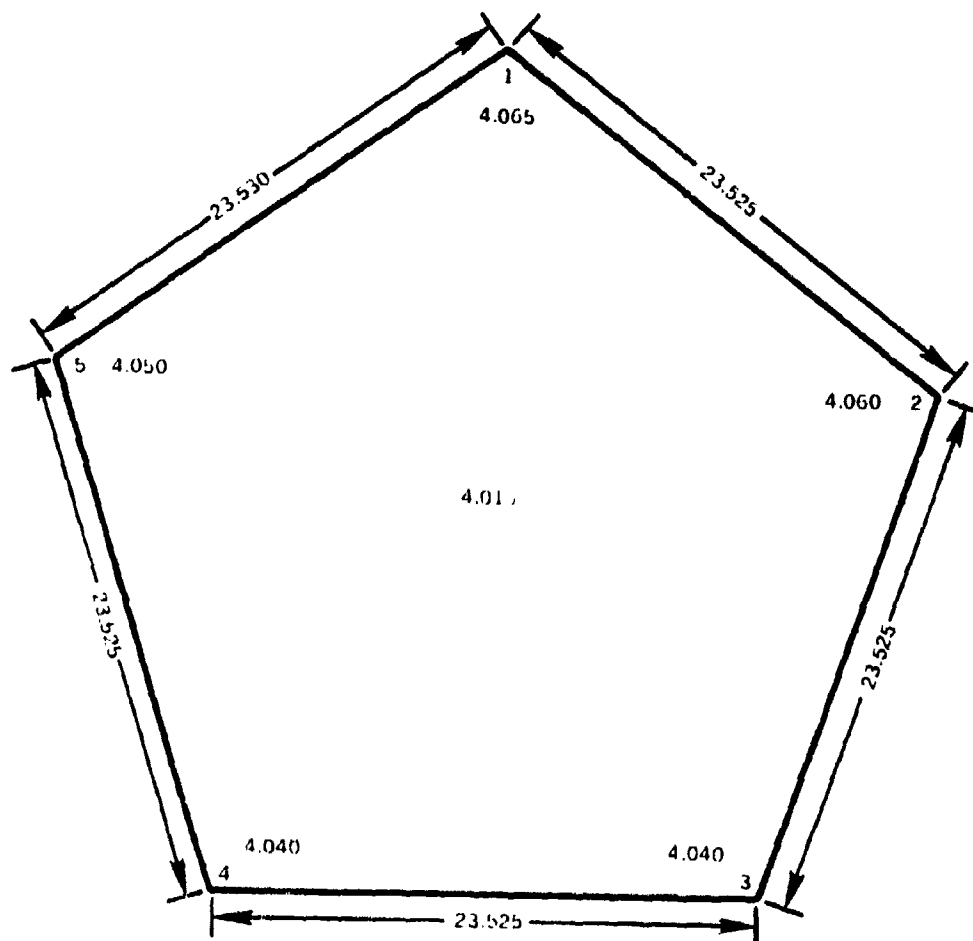
Enclosure 5B



Thickness After Annealing

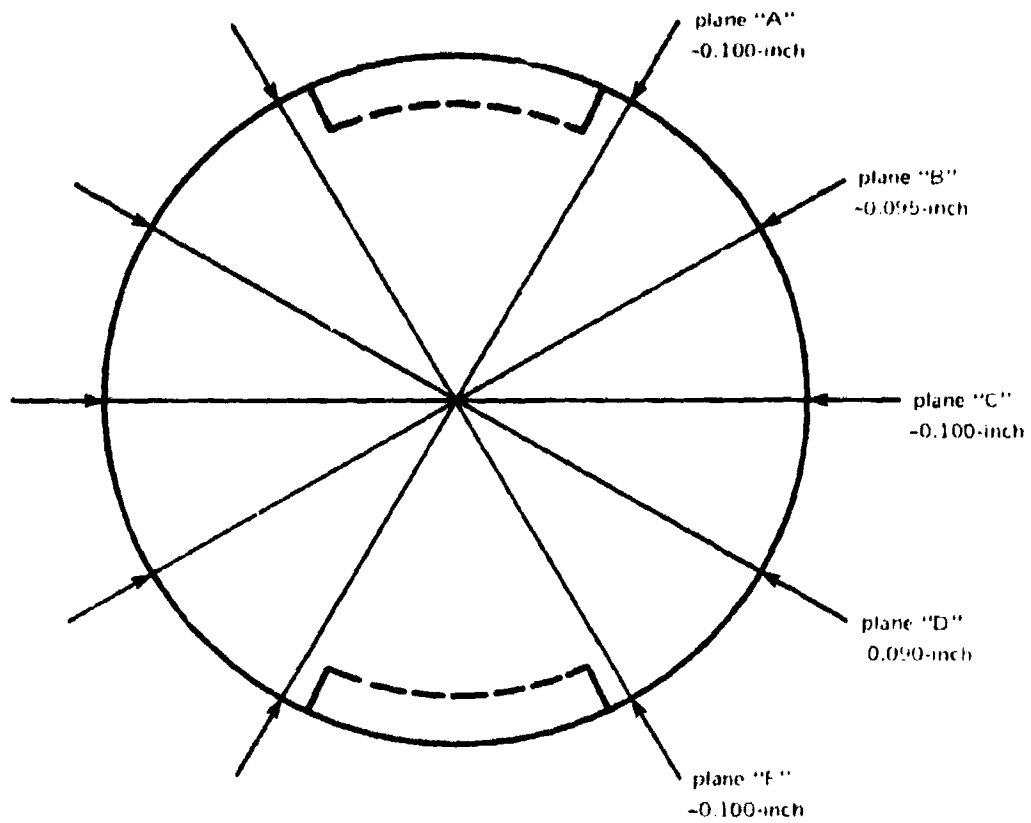


Enclosure 8B



Thickness After Machining

Enclosure 9B



Diameter of the Finished Sphere

APPENDIX C. DATA FROM HYDROSTATIC TESTS

Both the 15-inch OD \times 13-inch ID scale Model 34 and the 66-inch OD \times 58-inch ID full scale Model 2000 Nemo Hulls were extensively instrumented with strain-gages (see Figs. 20 and 23 of main text) so that their structural performance under external hydrostatic pressure could be accurately measured and evaluated. Highlights of that data have been summarized (see Tables 4, 5 and 6) and discussed in the main body of the report.

Still, other researchers in the field of acrylic plastic pressure hulls may need to refer to some specific detail of that data not provided in the main body of the report. For this reason the data generated during some of the more severe hydrostatic tests has been selected for presentation here in Appendix C. For the 15-inch OD \times 13-inch ID scale Model 34 the most severe as well as the most important test was pressurizing to implosion; this data is presented in Table 1C. The 66-inch OD \times 58-inch ID full scale Model 2000 Nemo Hull has not been tested to implosion therefore this data is not available. Instead, the data from the long term pressurization cycles to 1350 and 1800 psi are shown in Tables 2C and 3C.

Data from 15-inch OD \times 13-inch ID Model 34

Data Recording

The strain data was generated by subjecting the 15-inch OD \times 13-inch ID Model 34 to external hydrostatic pressure rising at 100 psi/minute rate. During recording of strain data (which took about 2 minutes per recording) the pressure was held constant. The temperature of water used in pressurizing of Model 34 was in the 70-75°F range.

Data Interpretation

The most important observation that can be made of the strain data from Model 34 is that all the strains measured on the acrylic plastic as well as on aluminum were linear to well over 1400 psi, indicating that both materials were still in the elastic range when the simulated depth passed the 3000-foot mark. At simulated depth of 4000 feet most of the strains became markedly non-linear, and at 5000 feet the strains became exponential.

The linear behavior of strains to depths in the 3000-3300 foot range substantiates the postulate that the Model 2000 Nemo Hull design (and its scaled down version Nemo Model 34) is operationally safe to 3000 feet as all of the materials in the hull respond elastically in the 0-3000 foot range.

Data from 66-Inch OD X 58-Inch ID Model 2000 Nemo Hull

Data Recording

The strain data was generated by subjecting the 66-inch OD X 58-inch ID Model 2000 Nemo Hull to external hydrostatic pressure rising at 100 psi/minute rate. During recording of strain data (which took about 2 minutes per recording), the pressure was held constant. The temperature of water used in pressurizing of the Model 2000 Nemo Hull was in the 70-75°F range.

Once the maximum pressure was reached further pressurization was stopped and the maximum pressure maintained for 24 hours. Readings were taken at 6 hour intervals, but only the last reading (taken 24 hours after initiation of long term loading) is shown on the data printout.

Readings were taken also during the depressurization which took place at 100 psi/minute rate. Upon reaching 0 pressure the Model 2000 Nemo Hull assembly was allowed to relax for 24 hours while readings were taken every 6 hours (only the last relaxation reading is shown in the data printout).

Data Interpretation

The strains are linear to 3000 feet. The creep in acrylic plastic after 24 hours of sustained loading at 3000 feet was less than 20 percent of the short term strain at that depth. After reduction of pressure to 0 psi and 24 hour relaxation at 0 psi all strains returned to zero. Both the linearity of strain in the 0-3000 foot range and return of strains to zero at conclusion of the pressure cycle indicate that the Model 2000 Nemo Hull can be repeatedly pressurized without permanent deformation to 3000 feet.

When pressurized to 4000 feet there was some nonlinearity at depths beyond 3500 feet. The creep in acrylic plastic after 24 hours of sustained loading at 4000 feet was about 30 percent of the short term strain at that depth. After reduction of pressure to 0 and 24 hours of relaxation at 0 pressure most of the strains in acrylic and aluminum return essentially to zero (are within ± 100 microinches of original zero). Only at some interior locations on aluminum components (location 6, 13, 14) were the remaining stresses positive and significantly high. No explanation has been found for their tensile character, or large magnitude.

The indications of nonlinearity during pressurization in the 3500-4000 foot depth range, excessive creep during long term pressurization at 4000 feet, and residual strains after relaxation at 0 depth indicate that pressurization of the Model 2000 Nemo Hull to 4000 feet subjects the assembly to excessive stresses. It is therefore postulated that the Model 2000 Nemo Hull assembly should not be proof-tested in excess of 3600 feet for service at depths to 3300 feet.

Table 1C. Strains Measured on 1.5-Inch OD x 1.3-Inch ID Nemo Model 34

Load Psi	Gage No.	1-1-C	1-1-I	1B-C	1B-I	2B-C	2B-I	3B-C	3B-I	Gage No.	4-4-C	4-4-I
0		0	0	0	0	0	0	0	0		0	0
100		-500	-500	-550	-500	-1,800	-900	-80	0		-50	-50
200		-1,100	-1,000	-1,150	-1,100	-1,250	-2,100	-170	+10		-75	-75
300		-1,400	-1,500	-1,700	-1,800	-1,900	-2,700	-250	+20		-100	-100
400		-1,800	-1,900	-2,250	-2,350	-2,300	-3,300	-330	+30		-115	-120
500		-2,200	-2,250	-2,800	-2,900	-2,800	-3,950	-400	+50		-125	-130
600		-2,650	-2,650	-3,400	-3,500	-3,300	-4,600	-470	+70		-140	-150
700		-3,000	-3,050	-3,950	-4,000	-3,750	-5,100	-540	+90		-150	-150
800		-3,400	-3,400	-4,500	-4,500	-4,200	-5,750	-600	+110		-175	-150
900		-3,800	-3,800	-5,000	-5,100	-4,600	-6,400	-650	+130		-195	-120
1,000		-4,200	-4,200	-5,600	-5,700	-5,100	-7,050	-700	+150		-200	-100
1,100		-4,600	-4,600	-6,200	-6,200	-5,550	-7,650	-780	+150		-225	-75
1,200		-5,000	-5,000	-6,700	-6,800	-6,000	-8,350	-860	+150		-250	-50
1,300		-5,400	-5,400	-7,300	-7,300	-6,400	-8,950	-940	+150		-260	-30
1,400		-5,900	-5,800	-7,900	-7,900	-6,950	-9,700	-1,020	+130		-280	-20
1,500		-6,300	-6,200	-8,600	-8,500	-7,400	-10,400	-1,100	+110			
1,600		-6,700	-6,600	-9,100	-9,200	-7,900	-11,000	-1,190	+90			
1,700		-7,200	-7,000	-9,900	-9,900	-8,500	-11,850	-1,310	+70			
1,800		-7,750	-7,600	-10,600	-10,600	-9,200	-12,650	-1,400	+50			
1,900		-8,200	-8,000	-11,400	-11,500	-9,900	-13,600	-1,490	+30			
2,000		-8,800	-8,600	-12,200	-12,200	-10,500	-14,600	-1,600	+10			
2,200		-9,800	-9,500	-13,700	-13,800	-11,600	-16,500	-1,750	-10			
2,400		-10,000	-10,500	-15,200	-15,200	-12,800	-18,250	-1,900	-30			
2,600		-12,100	-11,700	-17,100	-17,800	-13,200	-21,000	-2,050	-50			
2,800		-13,400	-12,900	-18,600	-18,800	-15,800	-22,850	-2,150	-70			
3,200		-16,400	-15,600	-23,800	-22,700	-19,800	-28,900	-2,200	-90			
3,600		-18,600	-18,000	-27,100		-28,000	>-30,000	-2,250	-110			
4,000		-21,600	-20,200	>-30,000		>-30,000	>-30,000	-2,200	-120			

Location of gages shown on Figure 20, pg. 44.

Table 1C. (Continued).

Load Pst	Gage No. 4B-C	Gage No. 4B-I	5A-C	Gage No. 5A-I	5B-C	Gage No. 5B-I	6B-C	Gage No. 6B-I	7B-C	Gage No. 7B-I
0	0	0	0	0	0	0	0	0	0	0
100	-50	-180	-10	0	-80	-10	-800	-1,000	-90	90
200	-100	-300	-20	10	-160	-20	-1,500	-1,800	-210	150
300	-160	-400	-30	10	-240	-30	-2,000	-2,400	-300	150
400	-200	-500	-40	10	-330	-50	-2,500	-2,950	-400	190
500	-250	-590	-50	20	-410	-60	-3,000	-3,450	-490	190
600	-310	-700	-60	20	-490	-80	-3,600	-4,000	-590	220
700	-370	-790	-70	20	-570	-100	-4,100	-4,500	-600	230
800	-430	-900	-80	30	-650	-130	-4,600	-5,050	-710	230
900	-490	-1,010	-90	30	-710	-170	-5,100	-5,600	-900	240
1,000	-550	-1,100	-100	30	-780	-200	-5,700	-6,100	-1,000	240
1,100	-610	-1,190	-110	30	-840	-210	-6,150	-6,700	-1,110	240
1,200	-680	-1,270	-120	40	-920	-220	-6,800	-7,100	-1,220	250
1,300	-730	-1,350	-130	40	-1,000	-230	-7,200	-7,700	-1,330	250
1,400	-790	-1,430	-140	40	-1,090	-240	-7,800	-8,300	-1,440	250
1,500	-850	-1,520	-150	50	-1,180	-260	-8,250	-8,900	-1,550	270
1,600	-920	-1,620	-160	50	-1,280	-280	-8,750	-9,600	-1,600	290
1,700	-990	-1,710	-170	50	-1,320	-300	-9,300	-10,450	-1,720	320
1,800	-1,060	-1,800	-180	50	-1,370	-320	-9,900	-11,250	-1,830	350
1,900	-1,130	-1,950	-190	60	-1,550	-335	-10,600	-12,200	-1,900	430
2,000	-1,200	-2,050	-200	60	-1,630	-350	-11,200	-13,050	-2,020	500
2,200	-1,300	-2,400	-220	60	-1,800	-400	-12,500	-14,700	-2,270	600
2,400	-1,400	-2,600	-280	70	-2,000	-450	-13,900	-16,300	-2,470	700
2,600	-1,500	-2,800	-280	80	-2,200	-460	-15,700	-18,100	-2,700	850
2,800	-1,550	-2,900	-310	80	-2,340	-480	-17,550	-19,800	-2,860	900
3,200	-1,600	-3,100	-370	90	-2,500	-550	-23,100	-22,800	-3,250	1,000
3,600	-1,650	-3,250	-560	110	-2,500	-640	-27,500		-3,550	1,180
4,000	-1,600	-3,400	-530	120	-2,840	-550	>-30,000		-3,750	1,350

Table 2C. Strains Measured on the 60-Inch OD x 58-Inch ID Model 2000 Nemo Hull
Under 24-Hour Long Hydrostatic Loading of 1350 Psi

LOAD	POISSON'S RATIO		SIGMA		GAGE NO.'s	
	EP1	EP2	MAX	MIN	TAU	MAX
0	0	0	0	0	0	0
150	-300	-950	-329	-510	93	93
300	-450	-1700	-538	-845	179	179
450	-600	-2500	-762	-1305	271	271
600	-800	-3300	-1010	-1724	357	357
750	-950	-4100	-1233	-2133	450	450
900	-1150	-4900	-1481	-2552	536	536
1050	-1300	-5750	-1714	-2986	636	636
1200	-1850	-6350	-2040	-3376	693	693
*[1350	-2050	-7200	-2348	-3814	736	736
1350	-2000	-7500	-2381	-3952	786	786
1350	-2000	-7500	-2381	-3982	786	786
1200	-1850	-7300	-2271	-3829	779	779
1050	-1650	-6550	-2033	-3433	700	700
900	-1500	-5650	-1740	-2476	593	593
750	-1300	-4700	-1514	-2406	486	486
600	-1250	-3800	-1314	-2098	364	364
450	-900	-2950	-990	-1576	293	293
300	-700	-2070	-714	-1086	186	186
150	-450	-1180	-424	-618	93	93
**[0	-150	-350	-138	-195	29	29
0	0	0	0	0	0	0

*[denotes strains at the beginning and conclusion of 24 hour long sustained loading at 1350 psi

**[denotes strains at the beginning and conclusion of 24 hour long relaxation at 0 psi

EP1 - hoop orientation

EP2 - longitudinal orientation

Table 2C. (Continued).

E _s , %	LOAD	STRAIN REDUCTION OF A TWO GAGE ROSETTE			POISSONS RATIO, %	SIGMA, %		GAGE NO., 2-OUTSIDE
		EP1	EP2			MAX	MIN	TAU MAX
0	0	0	0		0	0	0	0
150	-200	-200	-700		-462	-462	-462	0
300	-1900	-1900	-1900		-433	-433	-433	0
450	-2100	-2100	-2050		-1390	-1390	-1376	-7
600	-2750	-2750	-2700		-2700	-1824	-1810	-7
750	-3450	-3450	-3400		-2290	-2290	-2276	-7
900	-4150	-4150	-4100		-2757	-2757	-2743	-7
1050	-4850	-4850	-4800		-3224	-3224	-3210	-7
1200	-5600	-5600	-5500		-3714	-3714	-3686	-14
1350	-6350	-6350	-6250		-4214	-4214	-4184	-14
1450	-7550	-7550	-7550		-5033	-5033	-5033	0
1350	-7550	-7550	-7550		-5033	-5033	-5033	0
1200	-7350	-7350	-7300		-4840	-4840	-4826	-7
1050	-6550	-6550	-6500		-4387	-4387	-4343	-7
900	-5750	-5750	-5700		-3824	-3824	-3810	-7
750	-4900	-4900	-4850		-3257	-3257	-3243	-7
600	-4050	-4050	-4000		-2690	-2690	-2676	-7
450	-3050	-3050	-2450		-2014	-2014	-1986	-14
300	-2150	-2150	-2100		-1424	-1424	-1410	-7
150	-1300	-1300	-1300		-867	-867	-867	0
0	-450	-450	-400		-290	-290	-276	-7
0	0	0	0		0	0	0	0

Location of gages shown on Figure 23, pg. 48.

Table 2C. (Continued).

STRAIN REDUCTION OF A TAU GAGE ROSETTE		POISSONS RATIOS .30				GAGE NO. 3-OUTSIDE	
E ₁ .40	LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX	
0	0	0	0	0	0	0	0
150	150	-200	-450	-276	-490	107	107
300	300	-400	-1650	-505	-862	174	174
450	450	-550	-2150	-710	-1224	257	257
600	600	-550	-3000	-881	-1552	336	336
750	750	-800	-3750	-1095	-1938	421	421
900	900	-450	-4500	-1310	-2324	507	507
1050	1050	-1100	-5250	-1524	-2710	593	593
1200	1200	-1200	-6000	-1714	-3026	686	686
1350	1350	-1350	-6400	-1900	-3400	750	750
1350	1350	-1350	-6450	-1967	-3507	800	800
1350	1350	-1350	-6450	-1967	-3567	800	800
1200	1200	-1300	-6000	-1914	-3406	706	706
1050	1050	-1200	-6050	-1724	-3110	643	643
900	900	-1050	-5300	-1510	-2724	607	607
750	750	-850	-4500	-1262	-2305	521	521
600	600	-700	-3650	-1024	-1871	421	421
450	450	-600	-2800	-814	-1448	314	314
300	300	-450	-1900	-576	-990	207	207
150	150	-200	-1050	-295	-538	121	121
0	0	0	-250	-48	-114	36	36
0	0	0	0	0	0	0	0

Table 2C. (Continued)

IN	LOAD	STRAIN REDUCTION OF A TWO GAGE ROSETTE			POISSONS RATIO, %		GAGE NO. 1 - OUTSIDE	
		EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX		
0	0	0	0	0	0	0		
150	150	-750	-700	-490	-476	-7		
300	300	-1400	-1350	-920	-910	-7		
450	450	-2050	-1950	-1350	-1310	-14		
600	600	-2750	-2600	-1800	-1762	-21		
750	750	-3400	-3300	-2240	-2210	-14		
900	900	-4050	-3900	-2670	-2629	-21		
1050	1050	-4800	-4600	-3162	-3104	-29		
1200	1200	-5500	-5250	-3619	-3540	-36		
1350	1350	-6200	-5950	-4086	-4019	-46		
1500	1500	-7000	-6750	-4548	-4474	-56		
1650	1650	-7800	-7400	-5040	-4974	-64		
1800	1800	-8600	-8200	-5540	-5474	-69		
2000	2000	-9450	-9150	-6150	-6157	-73		
2200	2200	-10300	-9950	-6710	-6624	-73		
2400	2400	-11200	-10800	-7343	-7057	-79		
2600	2600	-12100	-11700	-7995	-7530	-84		
2800	2800	-13000	-12600	-8629	-8171	-89		
3000	3000	-13950	-13500	-9271	-8829	-91		
3200	3200	-14900	-14500	-9924	-9476	-97		
3400	3400	-15900	-15500	-10574	-10110	-100		

Table 2C. (Continued).

E = 10,000	STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 5-OUTSIDE	
	LOAD	EP1	EP2	POISSON'S RATIO = .30	SIGMA MIN	TAU MAX
	0	0	0	0	0	0
	150	-50	-100	-879	-1266	192
	300	-100	-150	-1993	-1978	192
	450	-150	-150	-2193	-2193	0
	600	-200	-200	-2857	-2857	0
	750	-250	-200	-3407	-3022	-192
	900	-300	-250	-4121	-3736	-192
	1050	-300	-250	-4121	-3736	-192
	1200	-300	-300	-4286	-4286	0
	1350	-350	-350	-5000	-5000	0
		-350	-300	-4835	-4451	-192
	1350	-350	-300	-4835	-4451	-192
	1200	-300	-300	-4286	-4286	0
	1050	-300	-300	-4286	-4286	0
	900	-250	-250	-3571	-3571	0
	750	-250	-200	-3407	-3022	-192
	600	-200	-200	-2857	-2857	0
	450	-150	-150	-1978	-1593	-192
	300	-50	-100	-879	-1264	192
	150	-50	-50	-714	-714	0
	0	0	0	0	0	0
	0	0	0	0	0	0

Table 2C. (Continued).

LE 10.00	STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 3 = OUTSIDE
	LOAD	EP1	EP2	POISSON'S RATIOS, 30	
				SIGMA MAX	SIGMA MIN
0	0	0	0	0	0
150	-50	-50	-50	-214	-214
300	-100	-100	-150	-1543	-1978
450	-150	-150	-200	-2143	-2143
600	-200	-200	-250	-2857	-2857
750	-250	-250	-300	-3571	-3571
900	-300	-300	-350	-4121	-3734
1050	-350	-350	-400	-4835	-4451
1200	-400	-400	-450	-5549	-5165
1350	-450	-450	-500	-6264	-5879
1500	-500	-500	-550	-6979	-6594
1650	-550	-550	-600	-7694	-7309
1800	-600	-600	-650	-8409	-8024
1950	-650	-650	-700	-9124	-8739
2100	-700	-700	-750	-9839	-9454
2250	-750	-750	-800	-10554	-10169
2400	-800	-800	-850	-11269	-10884
2550	-850	-850	-900	-11984	-11599
2700	-900	-900	-950	-12699	-12314
2850	-950	-950	-1000	-13414	-13029
3000	-1000	-1000	-1050	-14129	-13744
3150	-1050	-1050	-1100	-14844	-14459
3300	-1100	-1100	-1150	-15559	-15174
3450	-1150	-1150	-1200	-16274	-15889
3600	-1200	-1200	-1250	-16989	-16604
3750	-1250	-1250	-1300	-17704	-17319
3900	-1300	-1300	-1350	-18419	-18034
4050	-1350	-1350	-1400	-19134	-18749
4200	-1400	-1400	-1450	-19849	-19464
4350	-1450	-1450	-1500	-20564	-20179
4500	-1500	-1500	-1550	-21279	-20894
4650	-1550	-1550	-1600	-21994	-21609
4800	-1600	-1600	-1650	-22709	-22324
4950	-1650	-1650	-1700	-23424	-23039
5100	-1700	-1700	-1750	-24139	-23754
5250	-1750	-1750	-1800	-24854	-24469
5400	-1800	-1800	-1850	-25569	-25184
5550	-1850	-1850	-1900	-26284	-25899
5700	-1900	-1900	-1950	-26999	-26614
5850	-1950	-1950	-2000	-27714	-27329
6000	-2000	-2000	-2050	-28429	-28044
6150	-2050	-2050	-2100	-29144	-28759
6300	-2100	-2100	-2150	-29859	-29474
6450	-2150	-2150	-2200	-30574	-30189
6600	-2200	-2200	-2250	-31289	-30904
6750	-2250	-2250	-2300	-32004	-31619
6900	-2300	-2300	-2350	-32719	-32334
7050	-2350	-2350	-2400	-33434	-33049
7200	-2400	-2400	-2450	-34149	-33764
7350	-2450	-2450	-2500	-34864	-34479
7500	-2500	-2500	-2550	-35579	-35194
7650	-2550	-2550	-2600	-36294	-35909
7800	-2600	-2600	-2650	-37009	-36624
7950	-2650	-2650	-2700	-37724	-37339
8100	-2700	-2700	-2750	-38439	-38054
8250	-2750	-2750	-2800	-39154	-38769
8400	-2800	-2800	-2850	-39869	-39484
8550	-2850	-2850	-2900	-40584	-40199
8700	-2900	-2900	-2950	-41299	-40914
8850	-2950	-2950	-3000	-42014	-41629
9000	-3000	-3000	-3050	-42729	-42344
9150	-3050	-3050	-3100	-43444	-43059
9300	-3100	-3100	-3150	-44159	-43774
9450	-3150	-3150	-3200	-44874	-44489
9600	-3200	-3200	-3250	-45589	-45204
9750	-3250	-3250	-3300	-46304	-45919
9900	-3300	-3300	-3350	-47019	-46634
10050	-3350	-3350	-3400	-47734	-47349
10200	-3400	-3400	-3450	-48449	-48064
10350	-3450	-3450	-3500	-49164	-48779
10500	-3500	-3500	-3550	-49879	-49494
10650	-3550	-3550	-3600	-50594	-50209
10800	-3600	-3600	-3650	-51309	-50924
10950	-3650	-3650	-3700	-52024	-51639
11100	-3700	-3700	-3750	-52739	-52354
11250	-3750	-3750	-3800	-53454	-53069
11400	-3800	-3800	-3850	-54169	-53784
11550	-3850	-3850	-3900	-54884	-54499
11700	-3900	-3900	-3950	-55599	-55214
11850	-3950	-3950	-4000	-56314	-55929
12000	-4000	-4000	-4050	-57029	-56644
12150	-4050	-4050	-4100	-57744	-57359
12300	-4100	-4100	-4150	-58459	-58074
12450	-4150	-4150	-4200	-59174	-58789
12600	-4200	-4200	-4250	-59889	-59504
12750	-4250	-4250	-4300	-60604	-60219
12900	-4300	-4300	-4350	-61319	-60934
13050	-4350	-4350	-4400	-62034	-61649
13200	-4400	-4400	-4450	-62749	-62364
13350	-4450	-4450	-4500	-63464	-63079
13500	-4500	-4500	-4550	-64179	-63794
13650	-4550	-4550	-4600	-64894	-64509
13800	-4600	-4600	-4650	-65609	-65224
13950	-4650	-4650	-4700	-66324	-65939
14100	-4700	-4700	-4750	-67039	-66654
14250	-4750	-4750	-4800	-67754	-67369
14400	-4800	-4800	-4850	-68469	-68084
14550	-4850	-4850	-4900	-69184	-68799
14700	-4900	-4900	-4950	-69899	-69514
14850	-4950	-4950	-5000	-70614	-70229
15000	-5000	-5000	-5050	-71329	-70944
15150	-5050	-5050	-5100	-72044	-71659
15300	-5100	-5100	-5150	-72759	-72374
15450	-5150	-5150	-5200	-73474	-73089
15600	-5200	-5200	-5250	-74189	-73804
15750	-5250	-5250	-5300	-74904	-74519
15900	-5300	-5300	-5350	-75619	-75234
16050	-5350	-5350	-5400	-76334	-75949
16200	-5400	-5400	-5450	-77049	-76664
16350	-5450	-5450	-5500	-77764	-77379
16500	-5500	-5500	-5550	-78479	-78094
16650	-5550	-5550	-5600	-79194	-78809
16800	-5600	-5600	-5650	-79909	-79524
16950	-5650	-5650	-5700	-80624	-80239
17100	-5700	-5700	-5750	-81339	-80954
17250	-5750	-5750	-5800	-82054	-81669
17400	-5800	-5800	-5850	-82769	-82384
17550	-5850	-5850	-5900	-83484	-83099
17700	-5900	-5900	-5950	-84199	-83814
17850	-5950	-5950	-6000	-84914	-84529
18000	-6000	-6000	-6050	-85629	-85244
18150	-6050	-6050	-6100	-86344	-85959
18300	-6100	-6100	-6150	-87059	-86674
18450	-6150	-6150	-6200	-87774	-87389
18600	-6200	-6200	-6250	-88489	-88104
18750	-6250	-6250	-6300	-89204	-88819
18900	-6300	-6300	-6350	-89919	-89534
19050	-6350	-6350	-6400	-90634	-90249
19200	-6400	-6400	-6450	-91349	-90964
19350	-6450	-6450	-6500	-92064	-91679
19500	-6500	-6500	-6550	-92779	-92394
19650	-6550	-6550	-6600	-93494	-93109
19800	-6600	-6600	-6650	-94209	-93824
19950	-6650	-6650	-6700	-94924	-94539
20100	-6700	-6700	-6750	-95639	-95254
20250	-6750	-6750	-6800	-96354	-95969
20400	-6800	-6800	-6850	-97069	-96684
20550	-6850	-6850	-6900	-97784	-97399
20700	-6900	-6900	-6950	-98499	-98114
20850	-6950	-6950	-7000	-99214	-98829
21000	-7000	-7000	-7050	-99929	-99544
21150	-7050	-7050	-7100	-100644	-100259
21300	-7100	-7100	-7150	-101359	-100974
21450	-7150	-7150	-7200	-102074	-101689
21600	-7200	-7200	-7250	-102789	-102404
21750	-7250	-7250	-7300	-103504	-103119
21900	-7300	-7300	-7350	-104219	-103834
22050	-7350	-7350	-7400	-104934	-104549
22200	-7400	-7400	-7450	-105649	-105264
22350	-7450	-7450	-7500	-106364	-105979
22500	-7500	-7500	-7550	-107079	-106694
22650	-7550	-7550	-7600	-107794	-107409
22800	-7600	-7600	-7650	-108509	-108124
22950	-7650	-7650	-7700	-109224	-108839
23100	-7700	-7700	-7750	-109939	-109554
23250	-7750	-7750	-7800	-110654	-110269
23400	-7800	-7800	-7850	-111369	-110984
23550	-7850	-7850	-7900	-112084	-111699
23700	-7900	-7900	-7950	-112799	-112414
23850	-7950	-7950	-8000	-113514	-113129
24000	-8000	-8000	-8050	-114229	-113844
24150	-8050	-8050	-8100	-114944	-114559
24300	-8100	-8100	-8150	-115659	-115274
24450	-8150	-8150	-8200	-116374	-115989
24600	-8200	-8200	-8250	-117089	-116704
24750	-8250	-8250	-8300	-117804	-117419
24900	-8300	-8300	-8350	-118519	-118134
25050	-8350	-8350	-8400	-119234	-118849
25200	-8400	-8400	-8450	-119949	-119564
25350	-8450	-8450	-8500	-120664	-120279
25500	-8500	-8500	-8550	-121379	-120994
25650	-8550	-8550	-8600	-122094	-121709
25800	-8600	-8600	-8650	-122809	-122424
25950	-8650	-8650	-8700	-123524	-123139
26100	-8700	-8700	-8750	-124239	-123854
26250	-8750	-8750	-8800	-124954	-124569
26400	-8800	-8800	-8850	-125669	-125284
26550	-8850	-8850	-8900	-126384	-125999
26700	-8900	-8900	-8950	-127099	-126714
26850	-8950	-8950	-9000	-127814	-127429
27000	-9000	-9000	-9050	-128529	-128144
27150	-9050	-9050	-9100	-129244	-128859
27300	-9100	-9100	-9150	-129959	-129574
27450	-9150	-9150	-9200	-130674	-130289
27600	-9200	-9200	-9250	-131389	-131004
27750	-9250	-9250	-9300	-132104	-131719
27900	-9300	-9300	-9350	-132819	-132434
28050	-9350	-9350	-9400	-133534	-133149
28200	-9400	-9400	-9450	-134249	-133864
28350	-9450	-9450	-9500	-134964	-134579
28500	-9500	-9500	-9550	-135679	-135294
28650	-9550	-9550	-9600	-136394	-136009
28800	-9600	-9600	-9650	-137109	-136724
28950	-9650	-9650	-9700		

Table 2C. (Continued).

E = 10.00	STRAIN REDUCTION OF A TWO GAGE ROSETTE					GAGE NO. 2 - OUTSIDE	
	LOAD	EP1	EP2	SIGMA PAK	SIGMA MIN	TAU MAX	
	0	0	0	0	0	0	
	150	-100	-50	-1264	-874	-142	
	300	-150	-100	-1478	-1543	-142	
	450	-150	-150	-2143	-2143	0	
	600	-250	-200	-3407	-3022	-142	
	750	-300	-250	-4121	-3736	-142	
	900	-350	-300	-4835	-4451	-142	
	1050	-350	-350	-5000	-5000	0	
	1200	-400	-400	-5714	-5714	0	
	1350	-450	-450	-6429	-6429	0	
	1500	-450	-450	-6429	-6429	0	
	1650	-400	-450	-5874	-6429	142	
	1800	-350	-350	-5000	-5000	0	
	900	-350	-300	-4835	-4451	-142	
	750	-300	-250	-4121	-3736	-142	
	600	-250	-200	-3407	-3022	-142	
	450	-150	-150	-2143	-2143	0	
	300	-100	-100	-1478	-1478	0	
	150	-50	-50	-874	-874	0	
	0	0	0	0	0	0	

Table 2C. (Continued).

E = 10.00	STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 8 - OUTSIDE	
	LOAD	EP1	EP2	POISSONS RATIO, μ	SIGMA MAX	SIGMA MIN
	0	0	0		0	0
	150	-50	50		-385	385
	300	-100	50		-577	220
	450	-150	100		-862	604
	600	-200	100		-1154	440
	750	-250	100		-1446	275
	900	-300	100		-1731	110
	1050	-300	150		-1731	654
	1200	-350	100		-1731	-55
	1350	-350	100		-1731	-55
	1500	-300	100		-1538	110
	1650	-300	100		-1538	110
	1800	-300	100		-1538	110
	1950	-300	100		-1538	110
	2100	-250	50		-1334	-275
	2250	-250	50		-1334	-275
	2400	-200	100		-1154	440
	2550	-150	50		-962	55
	2700	-100	50		-764	220
	2850	-50	0		-577	-165
	3000	0	0		-385	0
	3150	0	0		-192	0
	3300	0	0		0	0

Table 2C. (Continued).

E = 10,000	LOAD	STRAIN REDUCTION OF A TWO GAGE ROSETTE			POISSONS RATIO, ν		SIGMA		GAGE NO. 8	GAGE NO. 9	OUTSIDE
		ϵ_{P1}	ϵ_{P2}	ϵ_{P3}	MAX	MIN	SIGMA	TAU			
	0	0	0	0	0	0	0	0	0	0	0
	150	-50	-100	-150	-879	-1269	142	142	142	142	142
	300	-100	-200	-300	-1543	-2198	142	142	142	142	142
	450	-150	-300	-450	-2308	-3242	385	385	385	385	385
	600	-200	-400	-600	-3187	-4456	577	577	577	577	577
	750	-250	-500	-750	-3352	-4670	577	577	577	577	577
	900	-300	-600	-900	-3401	-4670	577	577	577	577	577
	1050	-350	-700	-1050	-3401	-4670	577	577	577	577	577
	1200	-400	-800	-1200	-3401	-4670	577	577	577	577	577
	1350	-450	-900	-1350	-3401	-4670	577	577	577	577	577
	1500	-500	-1000	-1500	-3401	-4670	577	577	577	577	577
	1650	-550	-1100	-1650	-3401	-4670	577	577	577	577	577
	1800	-600	-1200	-1800	-3401	-4670	577	577	577	577	577
	1950	-650	-1300	-1950	-3401	-4670	577	577	577	577	577
	2100	-700	-1400	-2100	-3401	-4670	577	577	577	577	577
	2250	-750	-1500	-2250	-3401	-4670	577	577	577	577	577
	2400	-800	-1600	-2400	-3401	-4670	577	577	577	577	577
	2550	-850	-1700	-2550	-3401	-4670	577	577	577	577	577
	2700	-900	-1800	-2700	-3401	-4670	577	577	577	577	577
	2850	-950	-1900	-2850	-3401	-4670	577	577	577	577	577
	3000	-1000	-2000	-3000	-3401	-4670	577	577	577	577	577
	3150	-1050	-2100	-3150	-3401	-4670	577	577	577	577	577
	3300	-1100	-2200	-3300	-3401	-4670	577	577	577	577	577
	3450	-1150	-2300	-3450	-3401	-4670	577	577	577	577	577
	3600	-1200	-2400	-3600	-3401	-4670	577	577	577	577	577
	3750	-1250	-2500	-3750	-3401	-4670	577	577	577	577	577
	3900	-1300	-2600	-3900	-3401	-4670	577	577	577	577	577
	4050	-1350	-2700	-4050	-3401	-4670	577	577	577	577	577
	4200	-1400	-2800	-4200	-3401	-4670	577	577	577	577	577
	4350	-1450	-2900	-4350	-3401	-4670	577	577	577	577	577
	4500	-1500	-3000	-4500	-3401	-4670	577	577	577	577	577
	4650	-1550	-3100	-4650	-3401	-4670	577	577	577	577	577
	4800	-1600	-3200	-4800	-3401	-4670	577	577	577	577	577
	4950	-1650	-3300	-4950	-3401	-4670	577	577	577	577	577
	5100	-1700	-3400	-5100	-3401	-4670	577	577	577	577	577
	5250	-1750	-3500	-5250	-3401	-4670	577	577	577	577	577
	5400	-1800	-3600	-5400	-3401	-4670	577	577	577	577	577
	5550	-1850	-3700	-5550	-3401	-4670	577	577	577	577	577
	5700	-1900	-3800	-5700	-3401	-4670	577	577	577	577	577
	5850	-1950	-3900	-5850	-3401	-4670	577	577	577	577	577
	6000	-2000	-4000	-6000	-3401	-4670	577	577	577	577	577
	6150	-2050	-4100	-6150	-3401	-4670	577	577	577	577	577
	6300	-2100	-4200	-6300	-3401	-4670	577	577	577	577	577
	6450	-2150	-4300	-6450	-3401	-4670	577	577	577	577	577
	6600	-2200	-4400	-6600	-3401	-4670	577	577	577	577	577
	6750	-2250	-4500	-6750	-3401	-4670	577	577	577	577	577
	6900	-2300	-4600	-6900	-3401	-4670	577	577	577	577	577
	7050	-2350	-4700	-7050	-3401	-4670	577	577	577	577	577
	7200	-2400	-4800	-7200	-3401	-4670	577	577	577	577	577
	7350	-2450	-4900	-7350	-3401	-4670	577	577	577	577	577
	7500	-2500	-5000	-7500	-3401	-4670	577	577	577	577	577
	7650	-2550	-5100	-7650	-3401	-4670	577	577	577	577	577
	7800	-2600	-5200	-7800	-3401	-4670	577	577	577	577	577
	7950	-2650	-5300	-7950	-3401	-4670	577	577	577	577	577
	8100	-2700	-5400	-8100	-3401	-4670	577	577	577	577	577
	8250	-2750	-5500	-8250	-3401	-4670	577	577	577	577	577
	8400	-2800	-5600	-8400	-3401	-4670	577	577	577	577	577
	8550	-2850	-5700	-8550	-3401	-4670	577	577	577	577	577
	8700	-2900	-5800	-8700	-3401	-4670	577	577	577	577	577
	8850	-2950	-5900	-8850	-3401	-4670	577	577	577	577	577
	9000	-3000	-6000	-9000	-3401	-4670	577	577	577	577	577
	9150	-3050	-6100	-9150	-3401	-4670	577	577	577	577	577
	9300	-3100	-6200	-9300	-3401	-4670	577	577	577	577	577
	9450	-3150	-6300	-9450	-3401	-4670	577	577	577	577	577
	9600	-3200	-6400	-9600	-3401	-4670	577	577	577	577	577
	9750	-3250	-6500	-9750	-3401	-4670	577	577	577	577	577
	9900	-3300	-6600	-9900	-3401	-4670	577	577	577	577	577
	10050	-3350	-6700	-10050	-3401	-4670	577	577	577	577	577
	10200	-3400	-6800	-10200	-3401	-4670	577	577	577	577	577
	10350	-3450	-6900	-10350	-3401	-4670	577	577	577	577	577
	10500	-3500	-7000	-10500	-3401	-4670	577	577	577	577	577
	10650	-3550	-7100	-10650	-3401	-4670	577	577	577	577	577
	10800	-3600	-7200	-10800	-3401	-4670	577	577	577	577	577
	10950	-3650	-7300	-10950	-3401	-4670	577	577	577	577	577
	11100	-3700	-7400	-11100	-3401	-4670	577	577	577	577	577
	11250	-3750	-7500	-11250	-3401	-4670	577	577	577	577	577
	11400	-3800	-7600	-11400	-3401	-4670	577	577	577	577	577
	11550	-3850	-7700	-11550	-3401	-4670	577	577	577	577	577
	11700	-3900	-7800	-11700	-3401	-4670	577	577	577	577	577
	11850	-3950	-7900	-11850	-3401	-4670	577	577	577	577	577
	12000	-4000	-8000	-12000	-3401	-4670	577	577	577	577	577
	12150	-4050	-8100	-12150	-3401	-4670	577	577	577	577	577
	12300	-4100	-8200	-12300	-3401	-4670	577	577	577	577	577
	12450	-4150	-8300	-12450	-3401	-4670	577	577	577	577	577
	12600	-4200	-8400	-12600	-3401	-4670	577	577	577	577	577
	12750	-4250	-8500	-12750	-3401	-4670	577	577	577	577	577
	12900	-4300	-8600	-12900	-3401	-4670	577	577	577	577	577
	13050	-4350	-8700	-13050	-3401	-4670	577	577	577	577	577
	13200	-4400	-8800	-13200	-3401	-4670	577	577	577	577	577
	13350	-4450	-8900	-13350	-3401	-4670	577	577	577	577	577
	13500	-4500	-9000	-13500	-3401	-4670	577	577	577	577	577
	13650	-4550	-9100	-13650	-3401	-4670	577	577	577	577	577
	13800	-4600	-9200	-13800	-3401	-4670	577	577	577	577	577
	13950	-4650	-9300	-13950	-3401	-4670	577	577	577	577	577
	14100	-4700	-9400	-14100	-3401	-4670	577	577	577	577	577
	14250	-4750	-9500	-14250	-3401	-4670	577	577	577	577	577
	14400	-4800	-9600	-14400	-3401	-4670	577	577	577	577	577
	14550	-4850	-9700	-14550	-3401	-4670	577	577	577	577	577
	14700	-4900	-9800	-14700	-3401	-4670	577	577	577	577	577
	14850	-4950	-9900	-14850	-3401	-4670	577	577	577	577	577
	15000	-5000	-10000	-15000	-3401	-4670	577	577	577	577	577
	15150	-5050	-10100	-15150	-3401	-4670	577	577	577	577	577
	15300	-5100	-10200	-15300	-3401	-4670	577	577	577	577	577
	15450	-5150	-10300	-15450	-3401	-4670	577	577	577	577	577
	15600	-5200	-10400	-15600	-3401	-4670	577	577	577	577	577
	15750	-5250	-10500	-15750	-3401	-4670	577	577	577	577	577
	15900	-5300	-10600	-15900	-3401	-4670	577	577	577	577	577
	16050	-5350	-10700	-16050	-3401	-4670	577	577	577	577	577
	16200	-5400	-10800	-16200	-3401	-4670	577	577	577	577	577
	16350	-5450	-10900	-16350	-3401	-4670	577	577	577	577	577
	16500	-5500	-11000	-16500	-3401	-4670	577	577	577	577	577
	16650	-5550	-11100	-16650	-3401	-4670	577	577	577	577	577
	16800	-5600	-11200	-16800	-3401	-4670	577	577	577	577	577
	16950	-5650	-11300	-16950	-3401	-4670	577	577	577	577	577
	17100	-5700	-11400	-171							

Table 2C. (Continued).

ES 10.00	STRAIN REDUCTION OF A TWO GAGE ROSETTE					GAGE NO. 8 10-OUTSIDE
LOAD	EP1	EP2	POISSONS RATIO	SIGMA MAX	SIGMA MIN	TAU MAX
0	0	0				
150	-50	-100		-879	-1264	192
300	-50	-150		-1044	-1613	385
450	-100	-150		-1643	-1928	192
600	-100	-150		-1643	-1928	192
750	-200	-200		-2057	-2057	0
900	-250	-200		-3407	-3022	-192
1050	-300	-250		-4121	-3736	-192
1200	-300	-250		-4121	-3736	-192
1350	-350	-250		-4670	-3901	-385
1500	-350	-250		-4670	-3901	-385
1650	-300	-250		-4121	-3736	-192
1800	-300	-250		-4121	-3736	-192
1950	-300	-200		-3407	-3022	-385
2100	-250	-150		-3242	-2973	-192
2250	-150	-100		-1978	-1593	-385
2400	-50	-50		-879	-1264	-192
2550	-50	-50		-879	-1264	192
2700	0	0		-214	-714	0
2850	0	0		0	0	0
3000	0	0		0	0	0

Table 2C. (Continued).

STRAIN REDUCTION OF A TWO GAGE ROSETTE				CASE NO. 11-OUTSIDE	
E = 10.00	POISSONS RATIO = .30			SIGMA	TAU
LOAD	EP2	EP1	SIGMA MAX	MIN	MAX
0	0	0	0	0	0
150	-50	-50	-714	-714	0
300	-50	-100	-1264	-879	-142
450	-100	-150	-1478	-1543	-142
600	-150	-200	-2692	-2308	-142
750	-200	-200	-2857	-2857	0
900	-200	-200	-2857	-2857	0
1050	-250	-250	-3571	-3571	0
1200	-250	-250	-3736	-4121	142
1350	-250	-250	-3736	-4171	142
1500	-300	-250	-3736	-4121	142
1350	-300	-250	-3736	-4121	142
1200	-300	-250	-3736	-4121	142
1050	-250	-250	-3571	-3571	0
900	-200	-200	-2857	-2857	0
750	-150	-150	-2143	-2143	0
600	-100	-100	-1478	-1478	0
450	-100	-100	-1478	-1478	-142
300	-50	-100	-1264	-879	0
150	-50	-50	-714	-714	-142
0	0	0	0	0	0
0	0	0	0	0	0

Table 2C. (Continued).

STRAIN REDUCTION OF A TWO CASE ROSETTE		POISSON'S RATIO = .30				GAGE NO. 8 12-OUTSIDE	
L = 10.00	LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX	
0	0	0	0	0	0	0	0
150	-50	-50	-50	-714	-714	0	0
300	-100	-100	-100	-1429	-1429	0	0
450	-150	-150	-100	-1478	-1478	-142	-142
600	-150	-150	-150	-2143	-2143	0	0
750	-200	-200	-150	-2492	-2308	-142	-142
900	-200	-200	-200	-2857	-2857	0	0
1050	-250	-250	-200	-3407	-3022	-142	-142
1200	-250	-250	-200	-3407	-3022	-142	-142
1350	-300	-300	-200	-3456	-3187	-385	-385
1500	-300	-300	-200	-3456	-3187	-385	-385
1650	-250	-250	-200	-3407	-3022	-142	-142
1800	-200	-200	-200	-2857	-2857	0	0
1950	-200	-200	-150	-2492	-2308	-142	-142
2100	-150	-150	-100	-1478	-1478	-142	-142
2250	-100	-100	-50	-1264	-879	-142	-142
2400	-50	-50	-50	-714	-714	0	0
2550	0	0	0	-549	-165	-142	-142
2700	0	0	0	0	0	0	0
2850	0	0	0	0	0	0	0

Table 2C. (Continued).

E = 10,000	STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 13-OUTSIDE	
	LOAD	EP1	EP2	POISSONS RATIO = .30 SIGMA MAX	SIGMA MIN	TAU MAX
0	0	0	0	0	0	0
150	150	-50	-100	-879	-1264	192
300	300	-100	-100	-1929	-1429	0
450	450	-100	-150	-1543	-1478	192
600	600	-150	-150	-2143	-2143	0
750	750	-150	-150	-2143	-2143	0
900	900	-200	-150	-2642	-2308	-192
1050	1050	-250	-150	-3242	-2473	-305
1200	1200	-300	-200	-3907	-3022	-192
1350	1350	-300	-200	-3956	-3167	-385
1500	1500	-500	-400	-6813	-6044	-585
1650	1650	-500	-400	-6813	-6044	-585
1800	1800	-450	-350	-6095	-5330	-385
900	900	-350	-300	-4935	-4451	-192
750	750	-250	-250	-3571	-3571	0
600	600	-200	-150	-2642	-2308	-192
450	450	-150	-100	-1978	-1843	-192
300	300	-50	-50	-1264	-879	-192
150	150	-50	-50	-714	-714	0
0	0	0	0	-714	-714	0
0	0	0	0	0	0	0

Table 2C. (Continued).

E = 10.00		STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 14-OUTSIDE	
LOAD	EP1	EP2	POISSON'S RATIO, .30	SIGMA MAX	SIGMA MIN	TAU MAX	
0	0	0		n	G		
150	-30	-100		-879	-1664	0	
300	-100	-150		-1543	-1478	142	
450	-150	-150		-2149	-2143	142	
600	-200	-150		-2642	-2308	0	
750	-250	-200		-3007	-3022	-142	
900	-250	-200		-3407	-3022	-142	
1050	-300	-250		-4121	-3736	-142	
1200	-300	-250		-4121	-3736	-142	
1350	-350	-250		-4670	-3901	-142	
	-550	-450		-7527	-6758	-385	
1350	-550	-450		-7527	-6758	-385	
1200	-500	-400		-6013	-6041	-385	
1050	-400	-300		-5385	-4615	-385	
900	-300	-200		-3956	-3187	-385	
750	-250	-150		-3242	-2473	-385	
600	-200	-100		-2642	-2308	-142	
450	-100	-50		-1429	-1429	0	
300	-50	-50		-879	-1264	142	
150	0	0		-714	-714	0	
0	0	0		0	0	0	
0	0	0		0	0	0	

Table 2C. (Continued).

E ₁	LOAD	STRAIN REDUCTION OF A TWO GAGE ROSETTE			POISSONS RATIO	SIGMA MAX	SIGMA MIN	GAGE NO. 1-14810t	
		EPI	EP2	TAU MAX					
0	0	0	0	0	0	0	0	0	0
150	150	-800	-1150	-600	-700	-700	-700	50	50
300	-1250	-1250	-2550	-1081	-1452	-1452	-1452	184	184
450	-1750	-1750	-4950	-1581	-2452	-2452	-2452	386	386
600	-2200	-2200	-6100	-2210	-3324	-3324	-3324	557	557
750	-2700	-2700	-7550	-2743	-4157	-4157	-4157	707	707
900	-3100	-3100	-9550	-3245	-5138	-5138	-5138	921	921
1050	-3400	-3400	-11250	-3742	-6005	-6005	-6005	1121	1121
1200	-4100	-4100	-12450	-4414	-6448	-6448	-6448	1264	1264
1350	-4550	-4550	-14200	-4986	-7414	-7414	-7414	1464	1464
1500	-5050	-5050	-16200	-5871	-9624	-9624	-9624	1874	1874
1650	-5050	-5050	-16200	-5871	-9624	-9624	-9624	1874	1874
1800	-4900	-4900	-17150	-5600	-9100	-9100	-9100	1780	1780
1950	-4750	-4750	-15250	-5167	-8167	-8167	-8167	1580	1580
2100	-4100	-4100	-12500	-4333	-6733	-6733	-6733	1280	1280
2250	-3750	-3750	-10750	-3833	-5833	-5833	-5833	1090	1090
2400	-3300	-3300	-8200	-3193	-4533	-4533	-4533	700	700
2550	-2900	-2900	-5550	-2414	-3148	-3148	-3148	364	364
2700	-2350	-2350	-3450	-1776	-2040	-2040	-2040	187	187
2850	-1800	-1800	-1450	-1086	-1214	-1214	-1214	64	64
3000	-450	-450	-1450	-490	-776	-776	-776	143	143
0	0	0	-50	-10	-24	-24	-24	7	7

Table 2C. (Continued).

E _z	LOAD	POISSONS RATIOS		SIGMA MAX	EAGE NO. 2 1-INCH IDE	
		TP1	TP2		SIGMA MIN	TAU MAX
0	0	0	0	0	0	0
150	150	-1000	-900	-600	-614	-14
300	300	-1900	-1700	-1224	-1171	-29
450	450	-2800	-2550	-1814	-1748	-36
600	600	-3750	-3400	-2433	-2333	-50
750	750	-4600	-4250	-3000	-2900	-50
900	900	-5550	-5050	-3605	-3462	-71
1050	1050	-6500	-5900	-4214	-4048	-86
1200	1200	-7500	-6850	-4876	-4690	-93
1350	1350	-8400	-7750	-5476	-5290	-93
1500	1500	-10250	-9700	-6633	-6333	-150
1350	1350	-10250	-9200	-6633	-6333	-180
1200	1200	-9050	-8650	-5957	-5893	-87
1050	1050	-7950	-7700	-5252	-5181	-96
900	900	-6900	-6750	-4571	-4524	-21
750	750	-5850	-5800	-3890	-3876	-7
600	600	-4700	-4900	-3171	-3224	29
450	450	-3550	-3850	-2424	-2510	43
300	300	-2400	-2700	-1752	-1781	14
150	150	-1650	-1450	-1062	-1085	-24
0	0	-600	-300	-343	-257	-43
0	0	-50	0	-24	-10	-7

Table 2C. (Continued).

E8	LOAD	STRAIN REDUCTION OF A TWO GAGE ROSETTE				POISSON'S RATIO, ν		GAGE NO. 3-INSIDE	
		EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX	TAU MIN	0	0
0	0	0	0	-533	0	0	0	0	0
150	-600	-600	-1300	-1010	-739	100	100	100	100
300	-1100	-1100	-2550	-1481	-1429	207	207	207	207
450	-1550	-1550	-3900	-1952	-2152	336	336	336	336
600	-2000	-2000	-5250	-2424	-2881	464	464	464	464
750	-2450	-2450	-6600	-2910	-3610	593	593	593	593
900	-2900	-2900	-7900	-3400	-4329	707	707	707	707
1050	-3400	-3400	-9350	-3900	-5100	850	850	850	850
1200	-3950	-3950	-10850	-4406	-5919	984	984	984	984
1350	-4500	-4500	-12300	-4986	-6719	1119	1119	1119	1119
1500	-5150	-5150	-15100	-5329	-8171	1421	1421	1421	1421
1650	-5850	-5850	-15100	-5329	-8171	1721	1721	1721	1721
1800	-6450	-6450	-19800	-5176	-7990	1907	1907	1907	1907
1950	-7300	-7300	-13050	-4533	-7033	1250	1250	1250	1250
2100	-8150	-8150	-11250	-3929	-6071	1071	1071	1071	1071
2250	-9000	-9000	-9550	-3319	-5140	919	919	919	919
2400	-9850	-9850	-7700	-2681	-4152	736	736	736	736
2550	-10700	-10700	-5850	-2067	-3167	550	550	550	550
2700	-11550	-11550	-4000	-1485	-2162	379	379	379	379
2850	-12400	-12400	-2150	-767	-1167	200	200	200	200
3000	-13250	-13250	-300	-129	-171	21	21	21	21
0	0	0	0	0	0	0	0	0	0

Table 2C. (Continued)

IN	LOAD	EP1	EP2	POISSONS RATION	%	SIGMA MAX	SIGMA MIN	TAU MAX	CASE NO. 4-INCH
	0	0	0			0	0	0	
	150	-1000	-900			-678	-678	0	
	300	-1950	-1750			-1262	-1205	0	
	450	-2850	-2600			-1852	-1781	0	
	600	-3750	-3500			-2452	-2381	0	
	750	-4700	-4350			-3067	-2967	0	
	900	-5650	-5250			-3690	-3576	0	
	1050	-6550	-6100			-4281	-4157	0	
	1200	-7500	-7100			-4948	-4818	0	
	1350	-8550	-8000			-5595	-5438	0	
	1500	-10000	-9500			-6762	-6505	0	
	1650	-10900	-9508			-6762	-6505	0	
	1800	-9950	-9350			-6519	-6348	0	
	1950	-8900	-8300			-5819	-5648	0	
	2100	-7850	-7250			-5071	-4929	0	
	2250	-6800	-6200			-4305	-4162	0	
	2400	-5950	-5050			-3557	-3493	0	
	2550	-4350	-3900			-2814	-2686	0	
	2700	-3150	-2700			-2014	-1886	0	
	2850	-2050	-1500			-1262	-1086	0	
	3000	-900	-300			-348	-276	0	
	3150	-50	0			-50	-10	0	

Table 2C. (Continued).

STRAIN REDUCTION OF A TWO GAGE ROSETTE		POISSON'S RATIO, .30				GAGE NO. 9-INSIDE	
LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX		
0	0	0	0	0	0		
150	-50	-50	-719	-719	0		
300	-150	-200	-2308	-2308	175		
450	-200	-300	-3187	-3187	305		
600	-300	-500	-4495	-4495	469		
750	-400	-600	-6379	-6379	769		
900	-450	-700	-7259	-7259	962		
1050	-500	-750	-7967	-7967	962		
1200	-650	-800	-9780	-9780	577		
1350	-700	-850	-10445	-10445	577		
1500	-600	-850	-9396	-11219	962		
1350	-600	-850	-9396	-11219	962		
1200	-600	-800	-9231	-10769	769		
1050	-550	-750	-8516	-10058	769		
900	-450	-650	-7088	-8626	769		
750	-400	-550	-6209	-7363	577		
600	-300	-450	-4788	-5839	577		
450	-150	-300	-2637	-3791	577		
300	-100	-200	-1758	-2527	305		
150	-50	-50	-719	-719	0		
0	0	0	0	0	0		
0	0	0	0	0	0		

Table 2C. (Continued).

E= 10.00		STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 8 4-INSIDE	
LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX		
0	0	0	0	0	0	0	0
150	-100	-100	-1429	-1429	385	0	0
300	-250	-350	-1901	-1901	577	0	0
450	-350	-500	-2495	-2495	769	0	0
600	-450	-650	-3088	-3088	1154	0	0
750	-500	-800	-3682	-3682	1346	0	0
900	-600	-900	-4275	-4275	1538	0	0
1050	-700	-1050	-4868	-4868	1731	0	0
1200	-800	-1200	-5462	-5462	1923	0	0
1350	-850	-1350	-6055	-6055	2115	0	0
1500	-950	-1400	-6648	-6648	2307	0	0
1650	-1000	-1500	-7242	-7242	2499	0	0
1800	-1100	-1600	-7835	-7835	2691	0	0
1950	-1200	-1700	-8429	-8429	2883	0	0
2100	-1300	-1800	-9022	-9022	3075	0	0
2250	-1400	-1900	-9616	-9616	3267	0	0
2400	-1500	-2000	-10209	-10209	3459	0	0
2550	-1600	-2100	-10803	-10803	3651	0	0
2700	-1700	-2200	-11396	-11396	3843	0	0
2850	-1800	-2300	-11990	-11990	4035	0	0
3000	-1900	-2400	-12583	-12583	4227	0	0
3150	-2000	-2500	-13177	-13177	4419	0	0
3300	-2100	-2600	-13770	-13770	4611	0	0
3450	-2200	-2700	-14364	-14364	4803	0	0
3600	-2300	-2800	-14957	-14957	4995	0	0
3750	-2400	-2900	-15551	-15551	5187	0	0
3900	-2500	-3000	-16144	-16144	5379	0	0
4050	-2600	-3100	-16738	-16738	5571	0	0
4200	-2700	-3200	-17331	-17331	5763	0	0
4350	-2800	-3300	-17925	-17925	5955	0	0
4500	-2900	-3400	-18518	-18518	6147	0	0
4650	-3000	-3500	-19112	-19112	6339	0	0
4800	-3100	-3600	-19705	-19705	6531	0	0
4950	-3200	-3700	-20299	-20299	6723	0	0
5100	-3300	-3800	-20892	-20892	6915	0	0
5250	-3400	-3900	-21486	-21486	7107	0	0
5400	-3500	-4000	-22079	-22079	7299	0	0
5550	-3600	-4100	-22673	-22673	7491	0	0
5700	-3700	-4200	-23266	-23266	7683	0	0
5850	-3800	-4300	-23860	-23860	7875	0	0
6000	-3900	-4400	-24453	-24453	8067	0	0
6150	-4000	-4500	-25047	-25047	8259	0	0
6300	-4100	-4600	-25640	-25640	8451	0	0
6450	-4200	-4700	-26234	-26234	8643	0	0
6600	-4300	-4800	-26827	-26827	8835	0	0
6750	-4400	-4900	-27421	-27421	9027	0	0
6900	-4500	-5000	-28014	-28014	9219	0	0
7050	-4600	-5100	-28608	-28608	9411	0	0
7200	-4700	-5200	-29201	-29201	9603	0	0
7350	-4800	-5300	-29795	-29795	9795	0	0
7500	-4900	-5400	-30388	-30388	9987	0	0
7650	-5000	-5500	-30982	-30982	10179	0	0
7800	-5100	-5600	-31575	-31575	10371	0	0
7950	-5200	-5700	-32169	-32169	10563	0	0
8100	-5300	-5800	-32762	-32762	10755	0	0
8250	-5400	-5900	-33356	-33356	10947	0	0
8400	-5500	-6000	-33949	-33949	11139	0	0
8550	-5600	-6100	-34543	-34543	11331	0	0
8700	-5700	-6200	-35136	-35136	11523	0	0
8850	-5800	-6300	-35730	-35730	11715	0	0
9000	-5900	-6400	-36323	-36323	11907	0	0
9150	-6000	-6500	-36917	-36917	12099	0	0
9300	-6100	-6600	-37510	-37510	12291	0	0
9450	-6200	-6700	-38104	-38104	12483	0	0
9600	-6300	-6800	-38697	-38697	12675	0	0
9750	-6400	-6900	-39291	-39291	12867	0	0
9900	-6500	-7000	-39884	-39884	13059	0	0
10050	-6600	-7100	-40478	-40478	13251	0	0
10200	-6700	-7200	-41071	-41071	13443	0	0
10350	-6800	-7300	-41665	-41665	13635	0	0
10500	-6900	-7400	-42258	-42258	13827	0	0
10650	-7000	-7500	-42852	-42852	14019	0	0
10800	-7100	-7600	-43445	-43445	14211	0	0
10950	-7200	-7700	-44039	-44039	14403	0	0
11100	-7300	-7800	-44632	-44632	14595	0	0
11250	-7400	-7900	-45226	-45226	14787	0	0
11400	-7500	-8000	-45819	-45819	14979	0	0
11550	-7600	-8100	-46413	-46413	15171	0	0
11700	-7700	-8200	-47006	-47006	15363	0	0
11850	-7800	-8300	-47600	-47600	15555	0	0
12000	-7900	-8400	-48193	-48193	15747	0	0
12150	-8000	-8500	-48787	-48787	15939	0	0
12300	-8100	-8600	-49380	-49380	16131	0	0
12450	-8200	-8700	-49974	-49974	16323	0	0
12600	-8300	-8800	-50567	-50567	16515	0	0
12750	-8400	-8900	-51161	-51161	16707	0	0
12900	-8500	-9000	-51754	-51754	16899	0	0
13050	-8600	-9100	-52348	-52348	17091	0	0
13200	-8700	-9200	-52941	-52941	17283	0	0
13350	-8800	-9300	-53535	-53535	17475	0	0
13500	-8900	-9400	-54128	-54128	17667	0	0
13650	-9000	-9500	-54722	-54722	17859	0	0
13800	-9100	-9600	-55315	-55315	18051	0	0
13950	-9200	-9700	-55909	-55909	18243	0	0
14100	-9300	-9800	-56502	-56502	18435	0	0
14250	-9400	-9900	-57096	-57096	18627	0	0
14400	-9500	-10000	-57689	-57689	18819	0	0
14550	-9600	-10100	-58283	-58283	19011	0	0
14700	-9700	-10200	-58876	-58876	19203	0	0
14850	-9800	-10300	-59470	-59470	19395	0	0
15000	-9900	-10400	-60063	-60063	19587	0	0
15150	-10000	-10500	-60657	-60657	19779	0	0
15300	-10100	-10600	-61250	-61250	19971	0	0
15450	-10200	-10700	-61844	-61844	20163	0	0
15600	-10300	-10800	-62437	-62437	20355	0	0
15750	-10400	-10900	-63031	-63031	20547	0	0
15900	-10500	-11000	-63624	-63624	20739	0	0
16050	-10600	-11100	-64218	-64218	20931	0	0
16200	-10700	-11200	-64811	-64811	21123	0	0
16350	-10800	-11300	-65405	-65405	21315	0	0
16500	-10900	-11400	-66000	-66000	21507	0	0
16650	-11000	-11500	-66593	-66593	21699	0	0
16800	-11100	-11600	-67187	-67187	21891	0	0
16950	-11200	-11700	-67780	-67780	22083	0	0
17100	-11300	-11800	-68374	-68374	22275	0	0
17250	-11400	-11900	-68967	-68967	22467	0	0
17400	-11500	-12000	-69561	-69561	22659	0	0
17550	-11600	-12100	-70154	-70154	22851	0	0
17700	-11700	-12200	-70748	-70748	23043	0	0
17850	-11800	-12300	-71341	-71341	23235	0	0
18000	-11900	-12400	-71935	-71935	23427	0	0
18150	-12000	-12500	-72528	-72528	23619	0	0
18300	-12100	-12600	-73122	-73122	23811	0	0
18450	-12200	-12700	-73715	-73715	24003	0	0
18600	-12300	-12800	-74309	-74309	24195	0	0
18750	-12400	-12900	-74902	-74902	24387	0	0
18900	-12500	-13000	-75496	-75496	24579	0	0
19050	-12600	-13100	-76089	-76089	24771	0	0
19200	-12700	-13200	-76683	-76683	24963	0	0
19350	-12800	-13300	-77276	-77276	25155	0	0
19500	-12900	-13400	-77870	-77870	25347	0	0
19650	-13000	-13500	-78463	-78463	25539	0	0
19800	-13100	-13600	-79057	-79057	25731	0	0
19950	-13200	-13700	-79650	-79650	25923	0	0
20							

Table 2C. (Continued).

E = 10.00	STRAIN REDUCTION OF A TWO GAGE ROSETTE				CAGE NO. 7-INSIDE	
	LOAD	EP1	EP2	POISSONS RATION .30	SIGMA MIN	TAU MAX
0	0	0	0	0	0	0
150	150	-100	-100	-1424	-1424	0
300	300	-200	-200	-2857	-2857	0
450	450	-300	-300	-4286	-4286	0
600	600	-450	-350	-6099	-5330	-385
750	750	-600	-450	-8077	-6423	-577
900	900	-700	-500	-9341	-7802	-764
1050	1050	-800	-550	-10604	-9001	-962
1200	1200	-900	-650	-12033	-10110	-1154
1350	1350	-1000	-700	-13247	-10484	-1530
1500	1500	-1000	-600	-12467	-9890	-1538
1350	1350	-1000	-600	-12467	-9890	-1154
1200	1200	-900	-500	-11048	-8560	-1154
1050	1050	-800	-500	-10440	-8132	-962
900	900	-700	-450	-9176	-7853	-764
750	750	-600	-400	-7912	-6374	-577
600	600	-500	-350	-6648	-5445	-385
450	450	-400	-300	-5385	-4615	-3022
300	300	-250	-200	-3407	-3022	-142
150	150	-100	-100	-1424	-1424	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Table 2C. (Continued).

E = 10.00		STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 2 8-14SIDE	
LOAD		EP1	EP2	POISSON'S RATIO, μ	SIGMA MAX	SIGMA MIN	TAU MAX
0	0	0	0	0	0	0	0
150	-100	-100	50	-939	220	-279	-637
300	-250	-250	50	-2582	-275	-275	-1184
450	-400	-400	100	-4866	-220	-220	-1423
600	-550	-550	100	-5714	-714	-714	-2500
750	-700	-700	200	-7833	-110	-110	-3462
900	-800	-800	250	-7467	110	110	-4038
1050	-950	-950	300	-9451	145	145	-4808
1200	-1050	-1050	100	-11204	-2463	-2463	-4423
1350	-1200	-1200	50	-13022	-3407	-3407	-4908
1500	-1200	-1200	0	-13187	-3456	-3456	-4615
1350	-1200	-1200	0	-13187	-3456	-3456	-4615
1200	-1100	-1100	100	-11750	-2927	-2927	-4615
1050	-1000	-1000	350	-9835	444	444	-6192
900	-850	-850	300	-8352	495	495	-4923
750	-700	-700	250	-6868	440	440	-3684
600	-550	-550	150	-5549	-155	-155	-2542
450	-400	-400	150	-3901	330	330	-2115
300	-250	-250	100	-2418	276	276	-1345
150	-100	-100	50	-934	220	220	-877
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Table 2C. (Continued).

E= 10.00	STRAIN REDUCTION OF A TWO GAGE ROSETTE				POISSONS RATIOS .30		GAGE NO. 8 9-INSIDE	
LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX			
0	0	0	0	0	0	0	0	
150	-50	-50	-714	-714	192	192	0	
300	-150	-200	-2508	-2508	385	385	0	
450	-200	-300	-3127	-3127	577	577	0	
600	-300	-450	-4700	-4700	962	962	0	
750	-350	-600	-5824	-5824	1344	1344	0	
900	-400	-750	-6868	-6868	1638	1638	0	
1050	-450	-850	-7747	-7747	2115	2115	0	
1200	-500	-1050	-8965	-8965	2308	2308	0	
1350	-600	-1200	-10544	-10544	2731	2731	0	
1500	-550	-1000	-9341	-9341	1731	1731	0	
1350	-850	-1800	-9341	-9341	1731	1731	0	
1200	-550	-1000	-9341	-9341	1731	1731	0	
1050	-450	-800	-7912	-7912	1530	1530	0	
900	-400	-600	-7033	-7033	1154	1154	0	
750	-350	-500	-5984	-5984	962	962	0	
600	-300	-350	-5445	-5445	769	769	0	
450	-250	-200	-3901	-3901	308	308	0	
300	-150	-100	-2308	-2308	192	192	0	
150	-50	-50	-874	-874	192	192	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	

Table 2C. (Continued).

E = 10.00		STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 8 10-INSIDE	
LOAD	EP1	EP2	POISSONS RATIO = .30	SIGMA MAX	SIGMA MIN	TAU MAX	TAU MIN
0	0	0	0	0	0	0	0
150	-100	-50	-1244	-874	-142	-142	-142
300	-200	-100	-2527	-1758	-385	-385	-385
450	-300	-150	-3956	-3187	-571	-571	-571
600	-350	-200	-4838	-4451	-714	-714	-714
750	-400	-250	-5714	-5214	-857	-857	-857
900	-450	-300	-6590	-6090	-1000	-1000	-1000
1050	-500	-350	-7466	-6966	-1143	-1143	-1143
1200	-550	-400	-8342	-7842	-1286	-1286	-1286
1350	-600	-450	-9218	-8718	-1429	-1429	-1429
1500	-650	-500	-10094	-9594	-1572	-1572	-1572
1650	-700	-550	-10970	-10470	-1715	-1715	-1715
1800	-750	-600	-11846	-11346	-1858	-1858	-1858
1950	-800	-650	-12722	-12222	-2001	-2001	-2001
2100	-850	-700	-13598	-13098	-2144	-2144	-2144
2250	-900	-750	-14474	-13974	-2287	-2287	-2287
2400	-950	-800	-15350	-14850	-2430	-2430	-2430
2550	-1000	-850	-16226	-15726	-2573	-2573	-2573
2700	-1050	-900	-17102	-16602	-2716	-2716	-2716
2850	-1100	-950	-17978	-17478	-2859	-2859	-2859
3000	-1150	-1000	-18854	-18354	-3002	-3002	-3002
3150	-1200	-1050	-19730	-19230	-3145	-3145	-3145
3300	-1250	-1100	-20606	-20106	-3288	-3288	-3288
3450	-1300	-1150	-21482	-20982	-3431	-3431	-3431
3600	-1350	-1200	-22358	-21858	-3574	-3574	-3574
3750	-1400	-1250	-23234	-22734	-3717	-3717	-3717
3900	-1450	-1300	-24110	-23610	-3860	-3860	-3860
4050	-1500	-1350	-24986	-24486	-4003	-4003	-4003
4200	-1550	-1400	-25862	-25362	-4146	-4146	-4146
4350	-1600	-1450	-26738	-26238	-4289	-4289	-4289
4500	-1650	-1500	-27614	-27114	-4432	-4432	-4432
4650	-1700	-1550	-28490	-27990	-4575	-4575	-4575
4800	-1750	-1600	-29366	-28866	-4718	-4718	-4718
4950	-1800	-1650	-30242	-29742	-4861	-4861	-4861
5100	-1850	-1700	-31118	-30618	-5004	-5004	-5004
5250	-1900	-1750	-31994	-31494	-5147	-5147	-5147
5400	-1950	-1800	-32870	-32370	-5290	-5290	-5290
5550	-2000	-1850	-33746	-33246	-5433	-5433	-5433
5700	-2050	-1900	-34622	-34122	-5576	-5576	-5576
5850	-2100	-1950	-35498	-34998	-5719	-5719	-5719
6000	-2150	-2000	-36374	-35874	-5862	-5862	-5862
6150	-2200	-2050	-37250	-36750	-6005	-6005	-6005
6300	-2250	-2100	-38126	-37626	-6148	-6148	-6148
6450	-2300	-2150	-39002	-38502	-6291	-6291	-6291
6600	-2350	-2200	-39878	-39378	-6434	-6434	-6434
6750	-2400	-2250	-40754	-40254	-6577	-6577	-6577
6900	-2450	-2300	-41630	-41130	-6720	-6720	-6720
7050	-2500	-2350	-42506	-42006	-6863	-6863	-6863
7200	-2550	-2400	-43382	-42882	-7006	-7006	-7006
7350	-2600	-2450	-44258	-43758	-7149	-7149	-7149
7500	-2650	-2500	-45134	-44634	-7292	-7292	-7292
7650	-2700	-2550	-46010	-45510	-7435	-7435	-7435
7800	-2750	-2600	-46886	-46386	-7578	-7578	-7578
7950	-2800	-2650	-47762	-47262	-7721	-7721	-7721
8100	-2850	-2700	-48638	-48138	-7864	-7864	-7864
8250	-2900	-2750	-49514	-49014	-8007	-8007	-8007
8400	-2950	-2800	-50390	-49890	-8150	-8150	-8150
8550	-3000	-2850	-51266	-50766	-8293	-8293	-8293
8700	-3050	-2900	-52142	-51642	-8436	-8436	-8436
8850	-3100	-2950	-53018	-52518	-8579	-8579	-8579
9000	-3150	-3000	-53894	-53394	-8722	-8722	-8722
9150	-3200	-3050	-54770	-54270	-8865	-8865	-8865
9300	-3250	-3100	-55646	-55146	-9008	-9008	-9008
9450	-3300	-3150	-56522	-56022	-9151	-9151	-9151
9600	-3350	-3200	-57398	-56898	-9294	-9294	-9294
9750	-3400	-3250	-58274	-57774	-9437	-9437	-9437
9900	-3450	-3300	-59150	-58650	-9580	-9580	-9580
10050	-3500	-3350	-60026	-59526	-9723	-9723	-9723
10200	-3550	-3400	-60902	-60402	-9866	-9866	-9866
10350	-3600	-3450	-61778	-61278	-10009	-10009	-10009
10500	-3650	-3500	-62654	-62154	-10152	-10152	-10152
10650	-3700	-3550	-63530	-63030	-10295	-10295	-10295
10800	-3750	-3600	-64406	-63906	-10438	-10438	-10438
10950	-3800	-3650	-65282	-64782	-10581	-10581	-10581
11100	-3850	-3700	-66158	-65658	-10724	-10724	-10724
11250	-3900	-3750	-67034	-66534	-10867	-10867	-10867
11400	-3950	-3800	-67910	-67410	-11010	-11010	-11010
11550	-4000	-3850	-68786	-68286	-11153	-11153	-11153
11700	-4050	-3900	-69662	-69162	-11296	-11296	-11296
11850	-4100	-3950	-70538	-69938	-11439	-11439	-11439
12000	-4150	-4000	-71414	-70814	-11582	-11582	-11582
12150	-4200	-4050	-72290	-71690	-11725	-11725	-11725
12300	-4250	-4100	-73166	-72566	-11868	-11868	-11868
12450	-4300	-4150	-74042	-73442	-12011	-12011	-12011
12600	-4350	-4200	-74918	-74318	-12154	-12154	-12154
12750	-4400	-4250	-75794	-75194	-12297	-12297	-12297
12900	-4450	-4300	-76670	-76070	-12440	-12440	-12440
13050	-4500	-4350	-77546	-76946	-12583	-12583	-12583
13200	-4550	-4400	-78422	-77822	-12726	-12726	-12726
13350	-4600	-4450	-79298	-78698	-12869	-12869	-12869
13500	-4650	-4500	-80174	-79574	-13012	-13012	-13012
13650	-4700	-4550	-81050	-80450	-13155	-13155	-13155
13800	-4750	-4600	-81926	-81326	-13298	-13298	-13298
13950	-4800	-4650	-82802	-82202	-13441	-13441	-13441
14100	-4850	-4700	-83678	-83078	-13584	-13584	-13584
14250	-4900	-4750	-84554	-83954	-13727	-13727	-13727
14400	-4950	-4800	-85430	-84830	-13870	-13870	-13870
14550	-5000	-4850	-86306	-85706	-14013	-14013	-14013
14700	-5050	-4900	-87182	-86582	-14156	-14156	-14156
14850	-5100	-4950	-88058	-87458	-14299	-14299	-14299
15000	-5150	-5000	-88934	-88334	-14442	-14442	-14442
15150	-5200	-5050	-89810	-89210	-14585	-14585	-14585
15300	-5250	-5100	-90686	-90086	-14728	-14728	-14728
15450	-5300	-5150	-91562	-90962	-14871	-14871	-14871
15600	-5350	-5200	-92438	-91838	-15014	-15014	-15014
15750	-5400	-5250	-93314	-92714	-15157	-15157	-15157
15900	-5450	-5300	-94190	-93590	-15300	-15300	-15300
16050	-5500	-5350	-95066	-94466	-15443	-15443	-15443
16200	-5550	-5400	-95942	-95342	-15586	-15586	-15586
16350	-5600	-5450	-96818	-96218	-15729	-15729	-15729
16500	-5650	-5500	-97694	-97094	-15872	-15872	-15872
16650	-5700	-5550	-98570	-97970	-16015	-16015	-16015
16800	-5750	-5600	-99446	-98846	-16158	-16158	-16158
16950	-5800	-5650	-100322	-99722	-16301	-16301	-16301
17100	-5850	-5700	-101198	-100598	-16444	-16444	-16444
17250	-5900	-5750	-102074	-101474	-16587	-16587	-16587
17400	-5950	-5800	-102950	-102350	-16730	-16730	-16730
17550	-6000	-5850	-103826	-103226	-16873	-16873	-16873
17700	-6050	-5900	-104702	-104102	-17016	-17016	-17016
17850	-6100	-5950	-105578	-104978	-17159	-17159	-17159
18000	-6150	-6000	-106454	-105854	-17302	-17302	-17302
18150	-6200	-6050	-107330	-106730	-17445	-17445	-17445
18300	-6250	-6100	-108206	-107606	-17588	-17588	-17588
18450	-6300	-6150	-109082	-108482	-17731	-17731	-17731
18600	-6350	-6200	-109958	-109358	-17874	-17874	-17874
18750	-6400	-6250	-110834	-110234	-18017	-18017	-18017
18900	-6450	-6300	-111710	-111110	-18160	-18160	-18160
19050	-6500	-6350	-112586	-111986	-18303	-18303	-18303
19200	-6550	-6400	-113462	-112862	-18446	-18446	-18446
19350	-6600	-6450	-114338	-113738	-18589	-18589	-18589
19500	-6650	-6500	-115214	-114614	-18732	-18732	-18732
19650	-6700	-6550	-116090	-115490	-18875	-18875	-18875
19800	-6750	-6600	-116966	-116366	-19018	-19018	-19018
19950	-6800	-6650	-117842	-117242	-19161	-19161	-19161
20100	-6850	-6700	-118718	-118118	-19304	-19304	-19304
20250	-6900	-6750	-119594	-118994	-19447	-19447	-19447
20400	-6950	-6800	-120470	-119870	-19590	-19590	-19590
20550	-7000	-6850	-121346	-120746	-19733	-19733	-19733
20700	-7050	-6900	-122222	-121622	-19876	-19876	-19876
20850	-7100	-6950	-123098	-122498	-20019	-20019	-20019
21000	-7150	-7000	-123974	-123374	-20162	-20162	-20162
21150	-7200	-7050	-124850	-124250	-20305	-20305	-20305
21300	-7250	-7100	-125726	-125126	-20448	-20448	-20448
21450	-7300	-7150	-126602	-126002	-20591	-20591	-20591
21600	-7350	-7200	-127478	-126878	-20734	-20734	-20734
21750	-7400	-7250	-128354	-127754	-20877	-20877	-20877
21900	-7450	-7300	-129230	-128630	-21020	-21020	-21020
22050	-7500	-7350	-130106	-129506	-21163	-21163	-

Table 2C. (Continued).

E _s 18,000	STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 11-JM8102	
	LOAD	EP1	EP2	POISSONS RATION, .30	SIGMA MIN	TAU MAX
	0	0	0		0	0
	150	-150	-50	-714	-714	0
	300	-180	-200	-1750	-2527	385
	450	-200	-250	-3022	-3407	192
	600	-380	-350	-4451	-4835	192
	750	-480	-450	-5874	-6264	192
	900	-580	-550	-7308	-7692	192
	1050	-650	-600	-8822	-9407	192
	1200	-750	-700	-9451	-9836	192
	1350	-850	-750	-10165	-10644	192
	1500	-900	-750	-9066	-10220	577
	1650	-980	-750	-9066	-10220	577
	1800	-1000	-700	-8401	-9678	385
	1950	-550	-650	-8187	-8986	385
	2100	-500	-550	-7308	-7692	192
	2250	-450	-450	-6424	-6424	0
	2400	-350	-350	-5000	-5000	0
	2550	-250	-250	-3571	-3571	0
	2700	-150	-150	-2143	-2143	0
	2850	-50	-50	-714	-714	0
	3000	0	0	0	0	0
	3150	0	0	0	0	0

Table 20. (Continued).

E = 10,000	LOAD	STRAIN REDUCTION OF A TWO GAGE ROSETTE			CASE NO. 12-INSIDE	
		EP1	EP2	POISSONS RATIO, ν	SIGMA MIN	TAU MAX
	0	0	0	0	0	0
	150	-50	-50	-714	-714	0
	300	-150	-200	-2308	-2692	192
	450	-250	-250	-3571	-3571	0
	600	-300	-350	-4651	-4635	192
	750	-400	-450	-5879	-6264	192
	900	-500	-550	-7308	-7692	192
	1050	-600	-650	-8736	-9121	192
	1200	-700	-700	-10000	-10000	0
	1350	-800	-800	-11429	-11429	0
	1500	-900	-900	-11429	-11429	0
	1650	-1000	-1000	-11429	-11429	0
	1800	-1100	-1100	-11429	-11429	0
	1950	-1200	-1200	-11429	-11429	0
	2100	-1300	-1300	-11429	-11429	0
	2250	-1400	-1400	-11429	-11429	0
	2400	-1500	-1500	-11429	-11429	0
	2550	-1600	-1600	-11429	-11429	0
	2700	-1700	-1700	-11429	-11429	0
	2850	-1800	-1800	-11429	-11429	0
	3000	-1900	-1900	-11429	-11429	0
	3150	-2000	-2000	-11429	-11429	0
	3300	-2100	-2100	-11429	-11429	0
	3450	-2200	-2200	-11429	-11429	0
	3600	-2300	-2300	-11429	-11429	0
	3750	-2400	-2400	-11429	-11429	0
	3900	-2500	-2500	-11429	-11429	0
	4050	-2600	-2600	-11429	-11429	0
	4200	-2700	-2700	-11429	-11429	0
	4350	-2800	-2800	-11429	-11429	0
	4500	-2900	-2900	-11429	-11429	0
	4650	-3000	-3000	-11429	-11429	0
	4800	-3100	-3100	-11429	-11429	0
	4950	-3200	-3200	-11429	-11429	0
	5100	-3300	-3300	-11429	-11429	0
	5250	-3400	-3400	-11429	-11429	0
	5400	-3500	-3500	-11429	-11429	0
	5550	-3600	-3600	-11429	-11429	0
	5700	-3700	-3700	-11429	-11429	0
	5850	-3800	-3800	-11429	-11429	0
	6000	-3900	-3900	-11429	-11429	0
	6150	-4000	-4000	-11429	-11429	0
	6300	-4100	-4100	-11429	-11429	0
	6450	-4200	-4200	-11429	-11429	0
	6600	-4300	-4300	-11429	-11429	0
	6750	-4400	-4400	-11429	-11429	0
	6900	-4500	-4500	-11429	-11429	0
	7050	-4600	-4600	-11429	-11429	0
	7200	-4700	-4700	-11429	-11429	0
	7350	-4800	-4800	-11429	-11429	0
	7500	-4900	-4900	-11429	-11429	0
	7650	-5000	-5000	-11429	-11429	0
	7800	-5100	-5100	-11429	-11429	0
	7950	-5200	-5200	-11429	-11429	0
	8100	-5300	-5300	-11429	-11429	0
	8250	-5400	-5400	-11429	-11429	0
	8400	-5500	-5500	-11429	-11429	0
	8550	-5600	-5600	-11429	-11429	0
	8700	-5700	-5700	-11429	-11429	0
	8850	-5800	-5800	-11429	-11429	0
	9000	-5900	-5900	-11429	-11429	0
	9150	-6000	-6000	-11429	-11429	0
	9300	-6100	-6100	-11429	-11429	0
	9450	-6200	-6200	-11429	-11429	0
	9600	-6300	-6300	-11429	-11429	0
	9750	-6400	-6400	-11429	-11429	0
	9900	-6500	-6500	-11429	-11429	0
	10050	-6600	-6600	-11429	-11429	0
	10200	-6700	-6700	-11429	-11429	0
	10350	-6800	-6800	-11429	-11429	0
	10500	-6900	-6900	-11429	-11429	0
	10650	-7000	-7000	-11429	-11429	0
	10800	-7100	-7100	-11429	-11429	0
	10950	-7200	-7200	-11429	-11429	0
	11100	-7300	-7300	-11429	-11429	0
	11250	-7400	-7400	-11429	-11429	0
	11400	-7500	-7500	-11429	-11429	0
	11550	-7600	-7600	-11429	-11429	0
	11700	-7700	-7700	-11429	-11429	0
	11850	-7800	-7800	-11429	-11429	0
	12000	-7900	-7900	-11429	-11429	0
	12150	-8000	-8000	-11429	-11429	0
	12300	-8100	-8100	-11429	-11429	0
	12450	-8200	-8200	-11429	-11429	0
	12600	-8300	-8300	-11429	-11429	0
	12750	-8400	-8400	-11429	-11429	0
	12900	-8500	-8500	-11429	-11429	0
	13050	-8600	-8600	-11429	-11429	0
	13200	-8700	-8700	-11429	-11429	0
	13350	-8800	-8800	-11429	-11429	0
	13500	-8900	-8900	-11429	-11429	0
	13650	-9000	-9000	-11429	-11429	0
	13800	-9100	-9100	-11429	-11429	0
	13950	-9200	-9200	-11429	-11429	0
	14100	-9300	-9300	-11429	-11429	0
	14250	-9400	-9400	-11429	-11429	0
	14400	-9500	-9500	-11429	-11429	0
	14550	-9600	-9600	-11429	-11429	0
	14700	-9700	-9700	-11429	-11429	0
	14850	-9800	-9800	-11429	-11429	0
	15000	-9900	-9900	-11429	-11429	0
	15150	-10000	-10000	-11429	-11429	0
	15300	-10100	-10100	-11429	-11429	0
	15450	-10200	-10200	-11429	-11429	0
	15600	-10300	-10300	-11429	-11429	0
	15750	-10400	-10400	-11429	-11429	0
	15900	-10500	-10500	-11429	-11429	0
	16050	-10600	-10600	-11429	-11429	0
	16200	-10700	-10700	-11429	-11429	0
	16350	-10800	-10800	-11429	-11429	0
	16500	-10900	-10900	-11429	-11429	0
	16650	-11000	-11000	-11429	-11429	0
	16800	-11100	-11100	-11429	-11429	0
	16950	-11200	-11200	-11429	-11429	0
	17100	-11300	-11300	-11429	-11429	0
	17250	-11400	-11400	-11429	-11429	0
	17400	-11500	-11500	-11429	-11429	0
	17550	-11600	-11600	-11429	-11429	0
	17700	-11700	-11700	-11429	-11429	0
	17850	-11800	-11800	-11429	-11429	0
	18000	-11900	-11900	-11429	-11429	0
	18150	-12000	-12000	-11429	-11429	0
	18300	-12100	-12100	-11429	-11429	0
	18450	-12200	-12200	-11429	-11429	0
	18600	-12300	-12300	-11429	-11429	0
	18750	-12400	-12400	-11429	-11429	0
	18900	-12500	-12500	-11429	-11429	0
	19050	-12600	-12600	-11429	-11429	0
	19200	-12700	-12700	-11429	-11429	0
	19350	-12800	-12800	-11429	-11429	0
	19500	-12900	-12900	-11429	-11429	0
	19650	-13000	-13000	-11429	-11429	0
	19800	-13100	-13100	-11429	-11429	0
	19950	-13200	-13200	-11429	-11429	0
	20100	-13300	-13300	-11429	-11429	0
	20250	-13400	-13400	-11429	-11429	0
	20400	-13500	-13500	-11429	-11429	0
	20550	-13600	-13600	-11429	-11429	0
	20700	-13700	-13700	-11429	-11429	0
	20850	-13800	-13800	-11429	-11429	0
	21000	-13900	-13900	-11429	-11429	0
	21150	-14000	-14000	-11429	-11429	0
	21300	-14100	-14100	-11429	-11429	0
	21450	-14200	-14200	-11429	-11429	0
	21600	-14300	-14300	-11429	-11429	0
	21750	-14400	-14400	-11429	-11429	0
	21900	-14500	-14500	-11429	-11429	0
	22050	-14600	-14600	-11429	-11429	0
	22200	-14700	-14700	-11429	-11429	0
	22350	-14800	-14800	-11429	-11429	0
	22500	-14900	-14900	-11429	-11429	0
	22650	-15000	-15000	-11429	-11429	0
	22800	-15100	-15100	-11429	-11429	0
	22950	-15200	-15200	-11429	-11429	0
	23100	-15300	-15300	-11429	-11429	0
	23250	-15400	-15400	-11429	-11429	0
	23400	-15500	-15500	-11429	-11429	0
	23550	-15600	-15600	-11429	-11429	0
	23700	-15700	-15700	-11429	-11429	0
	23850	-15800	-15800	-11429	-11429	0
	24000	-15900	-15900	-11429	-11429	0
	24150	-16000	-16000	-11429	-11429	0
	24300	-16100	-16100	-11429	-11429	0
	24450	-16200	-16200	-11429	-11429	0
	24600	-16300	-16300	-11429	-11429	0
	24750	-16400	-16400	-11429	-11429	0
	24900	-16500	-16500	-11429	-11429	0
	25050	-16600	-16600	-11429	-11429	0
	25200	-16700	-16700	-11429	-11429	0
	25350	-16800	-16800	-11429	-11429	0
	25500	-16900	-16900	-11429	-11429	0
	25650	-17000	-17000	-11429	-11429	0
	25800	-17100	-17100	-11429	-11429	0
	25950	-17200	-17200	-11429	-11429	0
	26100	-17300	-17300	-11429	-11429	0
	26250	-17400	-17400	-11429	-11429	0
	26400	-17500	-17500	-11429	-11429	0
	26550	-17600	-17600	-11429	-11429	0
	26700	-17700	-17700	-11429	-11429	0
	26850	-17800	-17800	-11429	-11429	0
	27000	-17900	-17900	-11429	-11429	0
	27150	-18000	-18000	-11429	-11429	0
	27300	-18100	-18100	-11429	-11429	0
	27450	-18200	-18200	-11429	-11429	0
	27600	-18300	-18300	-11429	-11429	0
	27750	-18400	-18400	-11429	-11429	0
	27900	-18500	-18500	-11429	-11429	0
	28050	-18600	-18600	-11429	-11429	0

Table 2C. (Continued).

STRAIN REDUCTION OF A TWO GAGE ROSETTE		POISSONS RATIO = .30			GAGE NO. 8 13=INSIDE	
E = 10,000	LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX
	0	0	0	0	0	0
	150	-100	-100	-1029	-1029	0
	300	-200	-200	-2057	-2057	0
	450	-300	-300	-3086	-3086	0
	600	-400	-400	-4114	-4114	0
	750	-500	-500	-5143	-5143	0
	900	-550	-600	-6022	-6007	192
	1050	-600	-700	-8401	-8470	305
	1200	-700	-800	-10330	-11044	308
	1350	-800	-900	-11750	-12527	305
	1500	-900	-1050	-13362	-14005	577
	1650	-900	-1050	-13362	-14005	577
	1800	-800	-900	-11750	-12527	305
	1950	-700	-750	-10145	-10944	192
	2100	-600	-600	-8571	-8871	0
	2250	-500	-500	-7143	-7143	0
	2400	-400	-400	-5714	-5714	0
	2550	-300	-300	-4286	-4286	0
	2700	-200	-150	-2642	-2300	-192
	2850	-50	-50	-714	-714	0
	3000	0	0	0	0	0
	3150	0	0	0	0	0

Table 2C (Continued).

E = 10.00		STRAIN REDUCTION OF A TWO GAGE ROSETTE				GAGE NO. 1 = INSIDE	
LOAD	EP1	EP2	POISSONS RATIO = .30	SIGMA MAX	SIGMA MIN	TAU MAX	
0	0	0	0	0	0	0	0
150	-100	-50	-1264	-874	-192	-192	
300	-200	-150	-2542	-2308	-192	-192	
450	-300	-200	-3756	-3187	-385	-385	
600	-400	-300	-5385	-4615	-385	-385	
750	-500	-400	-6813	-6044	-385	-385	
900	-600	-500	-8242	-7473	-385	-385	
1050	-700	-600	-9670	-8901	-385	-385	
1200	-800	-700	-11264	-10879	-192	-192	
1350	-900	-800	-12642	-12308	-192	-192	
1500	-1000	-1000	-14286	-14286	0	0	
1350	-1000	-1000	-14286	-14286	-14286	0	
1200	-900	-800	-12642	-12308	-12308	-192	
1050	-750	-650	-10305	-9615	-9615	-385	
900	-650	-550	-8436	-8187	-8187	-385	
750	-500	-400	-6813	-6044	-6044	-385	
600	-400	-300	-5385	-4615	-4615	-385	
450	-300	-200	-3756	-3187	-3187	-385	
300	-200	-100	-2542	-2308	-2308	-192	
150	-100	-50	-1264	-874	-874	-192	
0	0	0	0	0	0	0	
0	0	0	0	0	0	0	

Table 30. Strains Measured on the 66-Inch OD X 58-Inch ID Model 2000 Nemo Hull
Under 24-Hour Long Sustained Loading of 1800 Psi

STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	POISSONS RATIO	SIGMA MAX	SIGMA MIN	GAGE NO. 9 I-OUTSIDE	TAU MAX
0	0	0	0	0	0	0	0
100	-250	-800	-271	-271	-929	79	79
200	-300	-1250	-261	-261	-652	136	136
300	-400	-1750	-320	-320	-910	193	193
400	-450	-2250	-663	-663	-1157	257	257
500	-550	-2750	-786	-786	-1310	319	319
600	-650	-3250	-929	-929	-1571	371	371
700	-750	-3850	-1090	-1090	-1976	443	443
800	-900	-4400	-1267	-1267	-2267	500	500
900	-1050	-4950	-1403	-1403	-2557	557	557
1000	-1100	-5450	-1662	-1662	-2806	621	621
1100	-1200	-6050	-1729	-1729	-3110	693	693
1200	-1350	-6500	-1881	-1881	-3352	736	736
1300	-1650	-6900	-2145	-2145	-3636	721	721
1400	-2000	-7400	-2362	-2362	-3906	791	791
1500	-2150	-8000	-2598	-2598	-4219	836	836
1600	-2300	-8700	-2752	-2752	-4581	919	919
1700	-2400	-9250	-2905	-2905	-4862	979	979
*[1800	-2500	-9750	-3098	-3098	-5119	1036	1036
	-2500	-10000	-3095	-3095	-5230	1071	1071
1800	-2500	-10000	-3095	-3095	-5230	1871	1871
1700	-2400	-9250	-2752	-2752	-4582	1816	1816
1600	-2300	-8700	-2598	-2598	-4219	986	986
1500	-2150	-8000	-2362	-2362	-3906	943	943
1400	-2000	-7400	-2145	-2145	-3636	900	900
1300	-1650	-6900	-1881	-1881	-3352	857	857
1200	-1350	-6500	-1729	-1729	-3110	819	819
1100	-1200	-6050	-1662	-1662	-2806	750	750
1000	-1100	-5450	-1403	-1403	-2557	671	671
900	-900	-4950	-1267	-1267	-2267	607	607
800	-750	-4400	-1090	-1090	-1976	543	543
700	-650	-3850	-929	-929	-1571	479	479
600	-550	-3250	-786	-786	-1310	419	419
500	-450	-2750	-663	-663	-1157	363	363
400	-400	-2250	-545	-545	-910	307	307
300	-300	-1750	-320	-320	-652	250	250
200	-250	-1250	-261	-261	-429	193	193
100	-200	-800	-200	-200	-276	136	136
**[0	0	0	0	0	0	79	79
**[.0	0	0	0	0	0	0	0

* denotes strains at the beginning and conclusion of 24 hour long sustained loading at 1900 psi

** denotes strains at the beginning and conclusion of 24 hour long sustained loading at 0 psi

Table 3C. (Continued).
STRAIN REDUCTIONS OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	POISSON'S RATIO, ν	SIGMA MAX	SIGMA MIN	GAGE NO. 1 OUTSIDE	TAU MAX
0	0	0	0	0	0	0	0
100	-0.50	-0.50	-0.30	-300	-300	-300	0
200	-0.50	-0.50	-0.26	-276	-276	-276	0
300	-1.35C	-1.35C	-0.00	-000	-000	-000	0
400	-1.750	-1.750	-0.167	-167	-167	-167	0
500	-2.250	-2.250	-1.500	-1500	-1500	-1500	0
600	-2.700	-2.700	-1.740	-1740	-1740	-1740	-7
700	-3.150	-3.150	-2.100	-2100	-2100	-2100	0
800	-3.600	-3.600	-2.400	-2400	-2400	-2400	0
900	-4.150	-4.150	-2.740	-2740	-2740	-2740	-10
1000	-4.550	-4.550	-3.020	-3020	-3020	-3020	-7
1100	-5.100	-5.100	-3.301	-3301	-3301	-3301	-10
1200	-5.500	-5.500	-3.657	-3657	-3657	-3657	-7
1300	-6.050	-6.050	-4.010	-4010	-4010	-4010	-10
1400	-6.550	-6.550	-4.348	-4348	-4348	-4348	-10
1500	-7.050	-7.050	-4.600	-4600	-4676	-4676	-7
1600	-7.550	-7.550	-5.001	-5001	-5052	-5052	-10
1700	-8.200	-8.200	-5.400	-5400	-5410	-5410	-10
1800	-8.650	-8.650	-5.757	-5757	-5749	-5749	-7
1900	-10.000	-10.000	-7.214	-7214	-7100	-7100	-36
2000	-10.400	-10.400	-7.214	-7214	-7100	-7100	-36
2100	-10.550	-10.550	-6.986	-6986	-6919	-6919	-20
2200	-10.650	-10.650	-6.662	-6662	-6605	-6605	-21
2300	-9.550	-9.550	-6.005	-6005	-6062	-6062	-21
2400	-8.200	-8.200	-6.105	-6105	-6062	-6062	-21
2500	-8.350	-8.350	-5.830	-5830	-5795	-5795	-21
2600	-7.900	-7.900	-5.530	-5530	-5495	-5495	-21
2700	-7.300	-7.300	-5.230	-5230	-5195	-5195	-21
2800	-6.700	-6.700	-4.930	-4930	-4895	-4895	-21
2900	-6.200	-6.200	-4.630	-4630	-4595	-4595	-21
3000	-5.550	-5.550	-4.340	-4340	-4310	-4310	-10
3100	-5.000	-5.000	-4.050	-4050	-4020	-4020	-10
3200	-4.450	-4.450	-3.750	-3750	-3720	-3720	-7
3300	-3.900	-3.900	-3.450	-3450	-3420	-3420	-7
3400	-3.350	-3.350	-3.150	-3150	-3120	-3120	-7
3500	-2.800	-2.800	-2.850	-2850	-2820	-2820	-7
3600	-2.250	-2.250	-2.550	-2550	-2520	-2520	-7
3700	-1.700	-1.700	-2.250	-2250	-2220	-2220	-7
3800	-1.150	-1.150	-1.950	-1950	-1920	-1920	-7
3900	-0.600	-0.600	-1.650	-1650	-1620	-1620	-7
4000	0	0	-1.350	-1350	-1320	-1320	-7
4100	0	0	-1.050	-1050	-1020	-1020	-7
4200	0	0	-0.750	-750	-720	-720	-7
4300	0	0	-0.450	-450	-420	-420	-7
4400	0	0	-0.150	-150	-120	-120	-7
4500	0	0	0	0	0	0	-7

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD lb.	EP1	EP2	POISSON'S RATIOS, %		SIGMA MIN	SIGMA MAX	CASE NO. 3-OUTSIDE	
							TAU MAX	
0	0	0	0	0	0	0	0	0
100	-100	-600	-100	-100	-305	71	71	
200	-200	-1100	-200	-305	-662	129	129	
300	-300	-1600	-300	-498	-814	186	186	
400	-400	-2000	-400	-571	-1029	229	229	
500	-500	-2500	-500	-714	-1206	286	286	
600	-600	-3000	-600	-857	-1493	343	343	
700	-700	-3500	-700	-998	-1776	393	393	
800	-770	-3900	-770	-1118	-2000	447	447	
900	-870	-4300	-870	-1252	-2261	500	500	
1000	-950	-4600	-950	-1386	-2519	559	559	
1100	-1050	-5050	-1050	-1530	-2795	629	629	
1200	-1100	-5400	-1100	-1690	-3019	686	686	
1300	-1200	-5800	-1200	-1798	-3276	743	743	
1400	-1300	-6200	-1300	-1933	-3533	800	800	
1500	-1400	-7400	-1400	-2076	-3790	857	857	
1600	-1500	-7900	-1500	-2219	-4000	919	919	
1700	-1600	-8050	-1600	-2362	-4305	971	971	
1800	-1700	-8800	-1700	-2484	-4519	1019	1019	
1900	-1650	-9150	-1650	-2529	-4671	1071	1071	
1000	-1650	-9150	-1650	-2529	-4671	1071	1071	
1700	-1550	-8800	-1550	-2419	-4606	1036	1036	
1600	-1500	-8400	-1500	-2319	-4520	986	986	
1500	-1400	-8000	-1400	-2150	-4376	943	943	
1400	-1350	-7650	-1350	-2100	-4300	900	900	
1300	-1250	-7200	-1250	-1967	-4167	850	850	
1200	-1200	-6850	-1200	-1876	-4040	807	807	
1100	-1100	-6400	-1100	-1793	-3857	757	757	
1000	-1000	-5900	-1000	-1600	-3600	700	700	
900	-900	-5400	-900	-1467	-3267	650	650	
800	-850	-5000	-850	-1357	-2593	593	593	
700	-750	-4550	-750	-1224	-2318	543	543	
600	-650	-4100	-650	-1090	-2076	493	493	
500	-550	-3600	-550	-998	-1819	436	436	
400	-450	-3100	-450	-805	-1562	379	379	
300	-350	-2600	-350	-662	-1305	321	321	
200	-200	-1900	-200	-467	-967	250	250	
100	-100	-1250	-100	-286	-619	169	169	
0	0	-550	-550	-162	-285	71	71	
0	0	300	300	57	103	-43	-43	

Table 3C. (Continued).

LOAD	EP1	EP2	POISSONS RATION ² %	SIGMA MAX	SIGMA MIN	TAU MAX	GAGE NO. 2 OUTSIDE
0	0	0		0	0	0	0
100	-0.50	-0.50		-300	-300	0	0
200	-0.50	-0.50		-562	-562	0	0
300	-1.350	-1.250		-881	-852	74	74
400	-1.750	-1.700		-1157	-1153	-27	-27
500	-2.250	-2.120		-1481	-1452	-124	-124
600	-2.650	-2.400		-1757	-1743	-27	-27
700	-3.150	-3.100		-2049	-2036	-27	-27
800	-3.600	-3.450		-2321	-2294	-21	-21
900	-4.050	-3.900		-2671	-2624	-21	-21
1000	-4.450	-4.300		-2995	-2945	-21	-21
1100	-5.000	-4.900		-3245	-3230	-24	-24
1200	-5.600	-5.250		-3545	-3530	-24	-24
1300	-5.950	-5.750		-3924	-3871	-24	-24
1400	-6.400	-6.200		-4224	-4171	-24	-24
1500	-6.900	-6.650		-4552	-4481	-36	-36
1600	-7.500	-7.200		-4941	-4854	-43	-43
1700	-8.050	-7.750		-5310	-5224	-43	-43
1800	-8.550	-8.200		-5633	-5533	-50	-50
1900	-10.000	-10.000		-6452	-6381	-64	-64
2000	-10.600	-10.000		-6724	-6701	-74	-74
2100	-10.250	-9.700		-6974	-6971	-74	-74
2200	-9.800	-9.250		-7171	-7164	-74	-74
2300	-9.400	-8.900		-7455	-7438	-74	-74
2400	-9.000	-8.550		-7681	-7652	-74	-74
2500	-8.500	-8.050		-7930	-7895	-74	-74
2600	-8.150	-7.650		-8010	-7960	-74	-74
2700	-7.800	-7.200		-8133	-8053	-74	-74
2800	-7.400	-6.700		-8257	-8143	-74	-74
2900	-6.500	-6.100		-8433	-8333	-74	-74
3000	-6.000	-5.650		-8650	-8533	-74	-74
3100	-5.450	-5.150		-8774	-8690	-74	-74
3200	-4.850	-4.550		-8930	-8840	-74	-74
3300	-4.300	-4.000		-9010	-8910	-74	-74
3400	-3.700	-3.450		-9114	-9014	-74	-74
3500	-3.100	-2.850		-9204	-9104	-74	-74
3600	-2.400	-2.200		-9280	-9180	-74	-74
3700	-1.750	-1.600		-9340	-9240	-74	-74
3800	-1.150	-1.000		-9450	-9350	-74	-74
3900	-0.550	-0.400		-9500	-9400	-74	-74
4000	0	0		-9500	-9400	-74	-74

Table XC. (Continued).

LOAD	EP1	EP2	POISSON'S RATIO, ν	STRAIN REDUCTION OF A TWO GAGE ROSETTE		GAGE NO., ν OUTSIDE
				SIGMA MAX	SIGMA MIN	TAU MAX
0	0	0	0	0	0	0
100	-50	-50	-0.714	-0.714	-0.714	0
200	-50	-50	-0.714	-0.714	-0.714	0
300	-100	-100	-1.429	-1.429	-1.429	0
400	-100	-100	-1.429	-1.429	-1.429	0
500	-150	-150	-2.143	-2.143	-2.143	0
600	-200	-200	-2.857	-2.857	-2.857	-1.42
700	-200	-200	-2.857	-2.857	-2.857	-1.42
800	-200	-200	-2.857	-2.857	-2.857	0
900	-250	-250	-3.571	-3.571	-3.571	0
1000	-250	-250	-3.571	-3.571	-3.571	-1.42
1100	-300	-300	-4.286	-4.286	-4.286	-1.42
1200	-300	-300	-4.286	-4.286	-4.286	-1.42
1300	-350	-350	-5.000	-5.000	-5.000	-1.42
1400	-350	-350	-5.000	-5.000	-5.000	-1.42
1500	-400	-400	-5.714	-5.714	-5.714	-1.42
1600	-400	-400	-5.714	-5.714	-5.714	-1.42
1700	-450	-450	-6.429	-6.429	-6.429	-1.42
1800	-450	-450	-6.429	-6.429	-6.429	-1.42
1900	-500	-500	-7.143	-7.143	-7.143	-1.42
2000	-500	-500	-7.143	-7.143	-7.143	-1.42
2100	-550	-550	-7.857	-7.857	-7.857	-1.42
2200	-550	-550	-7.857	-7.857	-7.857	-1.42
2300	-600	-600	-8.571	-8.571	-8.571	-1.42
2400	-600	-600	-8.571	-8.571	-8.571	-1.42
2500	-650	-650	-9.286	-9.286	-9.286	-1.42
2600	-650	-650	-9.286	-9.286	-9.286	-1.42
2700	-700	-700	-10.000	-10.000	-10.000	-1.42
2800	-700	-700	-10.000	-10.000	-10.000	-1.42
2900	-750	-750	-10.714	-10.714	-10.714	-1.42
3000	-750	-750	-10.714	-10.714	-10.714	-1.42
3100	-800	-800	-11.429	-11.429	-11.429	-1.42
3200	-800	-800	-11.429	-11.429	-11.429	-1.42
3300	-850	-850	-12.143	-12.143	-12.143	-1.42
3400	-850	-850	-12.143	-12.143	-12.143	-1.42
3500	-900	-900	-12.857	-12.857	-12.857	-1.42
3600	-900	-900	-12.857	-12.857	-12.857	-1.42
3700	-950	-950	-13.571	-13.571	-13.571	-1.42
3800	-950	-950	-13.571	-13.571	-13.571	-1.42
3900	-1000	-1000	-14.286	-14.286	-14.286	-1.42
4000	-1000	-1000	-14.286	-14.286	-14.286	-1.42
4100	-1050	-1050	-15.000	-15.000	-15.000	-1.42
4200	-1050	-1050	-15.000	-15.000	-15.000	-1.42
4300	-1100	-1100	-15.714	-15.714	-15.714	-1.42
4400	-1100	-1100	-15.714	-15.714	-15.714	-1.42
4500	-1150	-1150	-16.429	-16.429	-16.429	-1.42
4600	-1150	-1150	-16.429	-16.429	-16.429	-1.42
4700	-1200	-1200	-17.143	-17.143	-17.143	-1.42
4800	-1200	-1200	-17.143	-17.143	-17.143	-1.42
4900	-1250	-1250	-17.857	-17.857	-17.857	-1.42
5000	-1250	-1250	-17.857	-17.857	-17.857	-1.42
5100	-1300	-1300	-18.571	-18.571	-18.571	-1.42
5200	-1300	-1300	-18.571	-18.571	-18.571	-1.42
5300	-1350	-1350	-19.286	-19.286	-19.286	-1.42
5400	-1350	-1350	-19.286	-19.286	-19.286	-1.42
5500	-1400	-1400	-20.000	-20.000	-20.000	-1.42
5600	-1400	-1400	-20.000	-20.000	-20.000	-1.42
5700	-1450	-1450	-20.714	-20.714	-20.714	-1.42
5800	-1450	-1450	-20.714	-20.714	-20.714	-1.42
5900	-1500	-1500	-21.429	-21.429	-21.429	-1.42
6000	-1500	-1500	-21.429	-21.429	-21.429	-1.42
6100	-1550	-1550	-22.143	-22.143	-22.143	-1.42
6200	-1550	-1550	-22.143	-22.143	-22.143	-1.42
6300	-1600	-1600	-22.857	-22.857	-22.857	-1.42
6400	-1600	-1600	-22.857	-22.857	-22.857	-1.42
6500	-1650	-1650	-23.571	-23.571	-23.571	-1.42
6600	-1650	-1650	-23.571	-23.571	-23.571	-1.42
6700	-1700	-1700	-24.286	-24.286	-24.286	-1.42
6800	-1700	-1700	-24.286	-24.286	-24.286	-1.42
6900	-1750	-1750	-25.000	-25.000	-25.000	-1.42
7000	-1750	-1750	-25.000	-25.000	-25.000	-1.42
7100	-1800	-1800	-25.714	-25.714	-25.714	-1.42
7200	-1800	-1800	-25.714	-25.714	-25.714	-1.42
7300	-1850	-1850	-26.429	-26.429	-26.429	-1.42
7400	-1850	-1850	-26.429	-26.429	-26.429	-1.42
7500	-1900	-1900	-27.143	-27.143	-27.143	-1.42
7600	-1900	-1900	-27.143	-27.143	-27.143	-1.42
7700	-1950	-1950	-27.857	-27.857	-27.857	-1.42
7800	-1950	-1950	-27.857	-27.857	-27.857	-1.42
7900	-2000	-2000	-28.571	-28.571	-28.571	-1.42
8000	-2000	-2000	-28.571	-28.571	-28.571	-1.42
8100	-2050	-2050	-29.286	-29.286	-29.286	-1.42
8200	-2050	-2050	-29.286	-29.286	-29.286	-1.42
8300	-2100	-2100	-30.000	-30.000	-30.000	-1.42
8400	-2100	-2100	-30.000	-30.000	-30.000	-1.42
8500	-2150	-2150	-30.714	-30.714	-30.714	-1.42
8600	-2150	-2150	-30.714	-30.714	-30.714	-1.42
8700	-2200	-2200	-31.429	-31.429	-31.429	-1.42
8800	-2200	-2200	-31.429	-31.429	-31.429	-1.42
8900	-2250	-2250	-32.143	-32.143	-32.143	-1.42
9000	-2250	-2250	-32.143	-32.143	-32.143	-1.42
9100	-2300	-2300	-32.857	-32.857	-32.857	-1.42
9200	-2300	-2300	-32.857	-32.857	-32.857	-1.42
9300	-2350	-2350	-33.571	-33.571	-33.571	-1.42
9400	-2350	-2350	-33.571	-33.571	-33.571	-1.42
9500	-2400	-2400	-34.286	-34.286	-34.286	-1.42
9600	-2400	-2400	-34.286	-34.286	-34.286	-1.42
9700	-2450	-2450	-35.000	-35.000	-35.000	-1.42
9800	-2450	-2450	-35.000	-35.000	-35.000	-1.42
9900	-2500	-2500	-35.714	-35.714	-35.714	-1.42
10000	-2500	-2500	-35.714	-35.714	-35.714	-1.42

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	POISSONS RATIO = .30	SIGMA MAX	SIGMA MIN	GAGE NO. 6-OUTSIDE
0	0	0	0	0	0	TAU MAX
100	-50	-100	-879	-879	-1264	0
200	-50	-100	-879	-879	-1264	192
300	-100	-150	-1593	-1593	-1970	192
400	-100	-150	-1593	-1593	-1970	192
500	-150	-200	-2193	-2193	-2793	0
600	-200	-200	-2857	-2857	-3857	0
700	-200	-250	-3571	-3571	-4857	0
800	-250	-250	-4286	-4286	-5857	0
900	-300	-250	-4979	-4979	-6857	0
1000	-300	-300	-5693	-5693	-7857	192
1100	-350	-300	-6386	-6386	-8857	192
1200	-350	-350	-7093	-7093	-9857	192
1300	-400	-350	-7786	-7786	-10857	192
1400	-400	-400	-8493	-8493	-11857	192
1500	-450	-400	-9186	-9186	-12857	192
1600	-450	-450	-9893	-9893	-13857	192
1700	-500	-450	-10586	-10586	-14857	192
1800	-500	-500	-11293	-11293	-15857	192
1900	-550	-500	-11986	-11986	-16857	192
2000	-550	-550	-12693	-12693	-17857	192
2100	-600	-550	-13386	-13386	-18857	192
2200	-600	-600	-14093	-14093	-19857	192
2300	-650	-600	-14786	-14786	-20857	192
2400	-650	-650	-15493	-15493	-21857	192
2500	-700	-650	-16186	-16186	-22857	192
2600	-700	-700	-16893	-16893	-23857	192
2700	-750	-700	-17586	-17586	-24857	192
2800	-750	-750	-18293	-18293	-25857	192
2900	-800	-750	-18986	-18986	-26857	192
3000	-800	-800	-19693	-19693	-27857	192
3100	-850	-800	-20386	-20386	-28857	192
3200	-850	-850	-21093	-21093	-29857	192
3300	-900	-850	-21786	-21786	-30857	192
3400	-900	-900	-22493	-22493	-31857	192
3500	-950	-900	-23186	-23186	-32857	192
3600	-950	-950	-23893	-23893	-33857	192
3700	-1000	-950	-24586	-24586	-34857	192
3800	-1000	-1000	-25293	-25293	-35857	192
3900	-1050	-1000	-25986	-25986	-36857	192
4000	-1050	-1050	-26693	-26693	-37857	192
4100	-1100	-1050	-27386	-27386	-38857	192
4200	-1100	-1100	-28093	-28093	-39857	192
4300	-1150	-1100	-28786	-28786	-40857	192
4400	-1150	-1150	-29493	-29493	-41857	192
4500	-1200	-1150	-30186	-30186	-42857	192
4600	-1200	-1200	-30893	-30893	-43857	192
4700	-1250	-1200	-31586	-31586	-44857	192
4800	-1250	-1250	-32293	-32293	-45857	192
4900	-1300	-1250	-32986	-32986	-46857	192
5000	-1300	-1300	-33693	-33693	-47857	192
5100	-1350	-1300	-34386	-34386	-48857	192
5200	-1350	-1350	-35093	-35093	-49857	192
5300	-1400	-1350	-35786	-35786	-50857	192
5400	-1400	-1400	-36493	-36493	-51857	192
5500	-1450	-1400	-37186	-37186	-52857	192
5600	-1450	-1450	-37893	-37893	-53857	192
5700	-1500	-1450	-38586	-38586	-54857	192
5800	-1500	-1500	-39293	-39293	-55857	192
5900	-1550	-1500	-39986	-39986	-56857	192
6000	-1550	-1550	-40693	-40693	-57857	192
6100	-1600	-1550	-41386	-41386	-58857	192
6200	-1600	-1600	-42093	-42093	-59857	192
6300	-1650	-1600	-42786	-42786	-60857	192
6400	-1650	-1650	-43493	-43493	-61857	192
6500	-1700	-1650	-44186	-44186	-62857	192
6600	-1700	-1700	-44893	-44893	-63857	192
6700	-1750	-1700	-45586	-45586	-64857	192
6800	-1750	-1750	-46293	-46293	-65857	192
6900	-1800	-1750	-46986	-46986	-66857	192
7000	-1800	-1800	-47693	-47693	-67857	192
7100	-1850	-1800	-48386	-48386	-68857	192
7200	-1850	-1850	-49093	-49093	-69857	192
7300	-1900	-1850	-49786	-49786	-70857	192
7400	-1900	-1900	-50493	-50493	-71857	192
7500	-1950	-1900	-51186	-51186	-72857	192
7600	-1950	-1950	-51893	-51893	-73857	192
7700	-2000	-1950	-52586	-52586	-74857	192
7800	-2000	-2000	-53293	-53293	-75857	192
7900	-2050	-2000	-53986	-53986	-76857	192
8000	-2050	-2050	-54693	-54693	-77857	192
8100	-2100	-2050	-55386	-55386	-78857	192
8200	-2100	-2100	-56093	-56093	-79857	192
8300	-2150	-2100	-56786	-56786	-80857	192
8400	-2150	-2150	-57493	-57493	-81857	192
8500	-2200	-2150	-58186	-58186	-82857	192
8600	-2200	-2200	-58893	-58893	-83857	192
8700	-2250	-2200	-59586	-59586	-84857	192
8800	-2250	-2250	-60293	-60293	-85857	192
8900	-2300	-2250	-60986	-60986	-86857	192
9000	-2300	-2300	-61693	-61693	-87857	192
9100	-2350	-2300	-62386	-62386	-88857	192
9200	-2350	-2350	-63093	-63093	-89857	192
9300	-2400	-2350	-63786	-63786	-90857	192
9400	-2400	-2400	-64493	-64493	-91857	192
9500	-2450	-2400	-65186	-65186	-92857	192
9600	-2450	-2450	-65893	-65893	-93857	192
9700	-2500	-2450	-66586	-66586	-94857	192
9800	-2500	-2500	-67293	-67293	-95857	192
9900	-2550	-2500	-67986	-67986	-96857	192
10000	-2550	-2550	-68693	-68693	-97857	192

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

t = 10.00	LOAD	EP1	POISSONS RATIO = .30		SIGMA MIN	SIGMA MAX	GAGE NO. 8 7-OUTSIDE
			EP2	EP3			TAU MAX
0	0	0	0	0	0	0	0
100	100	-50	-50	-710	-710	0	0
200	200	-100	-50	-1260	-870	-192	-192
300	300	-150	-100	-1470	-1590	-192	-192
400	400	-200	-100	-1470	-1590	-192	-192
500	500	-250	-150	-2640	-2640	-192	-192
600	600	-250	-200	-3000	-3000	-192	-192
700	700	-250	-250	-3570	-3570	0	0
800	800	-300	-250	-4120	-3730	-192	-192
900	900	-300	-250	-4120	-3730	-192	-192
1000	1000	-350	-250	-4120	-3730	-192	-192
1100	1100	-350	-350	-5000	-5000	0	0
1200	1200	-350	-400	-5000	-5000	0	0
1300	1300	-400	-400	-5710	-5710	0	0
1400	1400	-400	-400	-5710	-5710	0	0
1500	1500	-450	-400	-6260	-5070	-192	-192
1600	1600	-500	-450	-6470	-6470	-192	-192
1700	1700	-500	-500	-7100	-7100	0	0
1800	1800	-550	-500	-7640	-7640	-192	-192
1900	1900	-550	-550	-7620	-7620	-305	-305
2000	2000	-550	-550	-7620	-7620	-305	-305
100	100	-550	-450	-7520	-6750	-305	-305
200	200	-500	-400	-6810	-6090	-305	-305
300	300	-450	-350	-6640	-5990	-377	-377
400	400	-400	-300	-6440	-5990	-377	-377
500	500	-350	-250	-5305	-6615	-305	-305
600	600	-300	-200	-5305	-6615	-305	-305
700	700	-250	-150	-5305	-6615	-305	-305
800	800	-200	-100	-5305	-6615	-305	-305
900	900	-150	-50	-5305	-6615	-305	-305
1000	1000	-100	0	-5305	-6615	-305	-305
1100	1100	-50	0	-5305	-6615	-305	-305
1200	1200	0	0	-5305	-6615	-305	-305
1300	1300	50	50	-5305	-6615	-305	-305
1400	1400	100	100	-5305	-6615	-305	-305
1500	1500	150	150	-5305	-6615	-305	-305
1600	1600	200	200	-5305	-6615	-305	-305
1700	1700	250	250	-5305	-6615	-305	-305
1800	1800	300	300	-5305	-6615	-305	-305
1900	1900	350	350	-5305	-6615	-305	-305
2000	2000	400	400	-5305	-6615	-305	-305
2100	2100	450	450	-5305	-6615	-305	-305
2200	2200	500	500	-5305	-6615	-305	-305
2300	2300	550	550	-5305	-6615	-305	-305
2400	2400	600	600	-5305	-6615	-305	-305
2500	2500	650	650	-5305	-6615	-305	-305
2600	2600	700	700	-5305	-6615	-305	-305
2700	2700	750	750	-5305	-6615	-305	-305
2800	2800	800	800	-5305	-6615	-305	-305
2900	2900	850	850	-5305	-6615	-305	-305
3000	3000	900	900	-5305	-6615	-305	-305
3100	3100	950	950	-5305	-6615	-305	-305
3200	3200	1000	1000	-5305	-6615	-305	-305
3300	3300	1050	1050	-5305	-6615	-305	-305
3400	3400	1100	1100	-5305	-6615	-305	-305
3500	3500	1150	1150	-5305	-6615	-305	-305
3600	3600	1200	1200	-5305	-6615	-305	-305
3700	3700	1250	1250	-5305	-6615	-305	-305
3800	3800	1300	1300	-5305	-6615	-305	-305
3900	3900	1350	1350	-5305	-6615	-305	-305
4000	4000	1400	1400	-5305	-6615	-305	-305
4100	4100	1450	1450	-5305	-6615	-305	-305
4200	4200	1500	1500	-5305	-6615	-305	-305
4300	4300	1550	1550	-5305	-6615	-305	-305
4400	4400	1600	1600	-5305	-6615	-305	-305
4500	4500	1650	1650	-5305	-6615	-305	-305
4600	4600	1700	1700	-5305	-6615	-305	-305
4700	4700	1750	1750	-5305	-6615	-305	-305
4800	4800	1800	1800	-5305	-6615	-305	-305
4900	4900	1850	1850	-5305	-6615	-305	-305
5000	5000	1900	1900	-5305	-6615	-305	-305

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	POISSONS RATIO, ν	SIGMA MAX	SIGMA MIN	TAU MAX	GAGE NO. 8-OUTSIDE
0	0	0	0	0	0	0	0
100	-50	50	0	-305	305	-305	-305
200	-100	100	0	-769	769	-769	-769
300	-150	100	0	-1319	604	-962	-962
400	-150	100	0	-1319	604	-962	-962
500	-150	100	0	-1319	604	-962	-962
600	-200	100	0	-1868	440	-1184	-1184
700	-200	100	0	-1868	440	-1184	-1184
800	-250	100	0	-2418	276	-1306	-1306
900	-250	100	0	-2418	276	-1306	-1306
1000	-250	100	0	-2418	276	-1306	-1306
1100	-300	150	0	-2802	659	-1538	-1538
1200	-300	200	0	-2637	1209	-1423	-1423
1300	-300	200	0	-3187	1899	-2115	-2115
1400	-350	200	0	-3022	1593	-2308	-2308
1500	-350	200	0	-3736	879	-2308	-2308
1600	-450	200	0	-4206	714	-2500	-2500
1700	-450	200	0	-4206	714	-2500	-2500
1800	-450	200	0	-4206	714	-2500	-2500
1900	-450	250	0	-3571	1929	-2500	-2500
2000	-450	250	0	-3571	1929	-2500	-2500
1000	-900	250	0	-3571	1929	-2500	-2500
1100	-900	200	0	-3187	1099	-2115	-2115
1200	-900	200	0	-3187	1099	-2115	-2115
1300	-900	150	0	-2802	659	-1538	-1538
1400	-900	200	0	-2088	1379	-1731	-1731
1500	-900	200	0	-2088	1379	-1731	-1731
1600	-900	200	0	-2088	1379	-1731	-1731
1700	-900	200	0	-2088	1379	-1731	-1731
1800	-900	200	0	-2088	1379	-1731	-1731
1900	-900	200	0	-2088	1379	-1731	-1731
2000	-900	200	0	-2088	1379	-1731	-1731
1000	-150	200	0	-989	1703	-1306	-1306
1100	-150	200	0	-989	1703	-1306	-1306
1200	-150	200	0	-989	1703	-1306	-1306
1300	-150	200	0	-989	1703	-1306	-1306
1400	-150	200	0	-989	1703	-1306	-1306
1500	-150	200	0	-989	1703	-1306	-1306
1600	-150	200	0	-989	1703	-1306	-1306
1700	-150	200	0	-989	1703	-1306	-1306
1800	-150	200	0	-989	1703	-1306	-1306
1900	-150	200	0	-989	1703	-1306	-1306
2000	-150	200	0	-989	1703	-1306	-1306
1000	-50	200	0	110	2033	-962	-962
1100	-50	150	0	-55	1499	-769	-769
1200	0	150	0	445	1699	-977	-977
1300	50	100	0	879	1264	-142	-142
1400	50	100	0	879	1264	-142	-142
1500	50	100	0	879	1264	-142	-142
1600	50	100	0	879	1264	-142	-142
1700	50	100	0	879	1264	-142	-142
1800	50	100	0	879	1264	-142	-142
1900	50	100	0	879	1264	-142	-142
2000	50	100	0	879	1264	-142	-142

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX	GAGE NO. 9-OUTSIDE
0	0	0	0	0	0	0
100	-50	-50	-719	-719	0	0
200	-50	-100	-879	-1269	192	192
300	-100	-150	-1593	-1978	192	192
400	-150	-150	-2193	-2193	0	0
500	-150	-200	-2308	-2692	192	192
600	-150	-200	-2308	-2692	192	192
700	-150	-200	-2308	-2692	192	192
800	-200	-250	-2822	-3407	192	192
900	-250	-250	-3671	-3671	0	0
1000	-250	-250	-3671	-3671	0	0
1100	-250	-300	-3726	-4121	192	192
1200	-250	-300	-3726	-4121	192	192
1300	-300	-350	-4451	-4835	192	192
1400	-300	-350	-4451	-4835	192	192
1500	-350	-400	-5165	-5599	192	192
1600	-350	-400	-5165	-5599	192	192
1700	-350	-450	-5337	-6099	303	303
1800	-400	-450	-5879	-6269	192	192
1900	-400	-450	-5879	-6269	192	192
1000	-400	-450	-5879	-6269	192	192
1700	-400	-400	-5719	-5719	0	0
1400	-400	-350	-5599	-5165	-192	-192
1500	-400	-350	-5599	-5165	-192	-192
1400	-350	-350	-5000	-5000	0	0
1300	-300	-300	-4951	-4835	192	192
1200	-300	-300	-4206	-4206	0	0
1100	-300	-250	-4121	-3726	-192	-192
1000	-250	-250	-3571	-3571	0	0
900	-250	-200	-3907	-3822	-192	-192
800	-200	-200	-2692	-2308	-192	-192
700	-200	-150	-2692	-2308	-192	-192
600	-200	-100	-2527	-1758	-303	-303
500	-100	-100	-1929	-1929	0	0
400	-100	-50	-1269	-879	-192	-192
300	-100	-50	-1269	-879	-192	-192
200	-50	0	-599	-165	-192	-192
100	0	50	165	599	-192	-192
0	50	150	1099	1813	-303	-303
0	0	50	165	599	-192	-192

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

E = 10.00	LOAD	EP1	EP2	POISSONS RATION, ν	SIGMA MAX	SIGMA MIN	TAU MAX	CAGE NO., 10-OUTSIDE
0	0	0	0	0	0	0	0	0
100	100	-50	-50	-0.714	-0.714	-0.714	0	0
200	200	-100	-100	-0.774	-0.774	-0.774	100	100
300	300	-150	-150	-0.824	-0.824	-0.824	0	0
400	400	-200	-200	-0.874	-0.874	-0.874	0	0
500	500	-250	-250	-0.924	-0.924	-0.924	-100	-100
600	600	-300	-300	-0.978	-0.978	-0.978	-100	-100
700	700	-350	-350	-1.032	-1.032	-1.032	-100	-100
800	800	-400	-400	-1.086	-1.086	-1.086	-100	-100
900	900	-450	-450	-1.140	-1.140	-1.140	-100	-100
1000	1000	-500	-500	-1.194	-1.194	-1.194	-100	-100
1100	1100	-550	-550	-1.248	-1.248	-1.248	-100	-100
1200	1200	-600	-600	-1.302	-1.302	-1.302	-100	-100
1300	1300	-650	-650	-1.356	-1.356	-1.356	-100	-100
1400	1400	-700	-700	-1.410	-1.410	-1.410	-100	-100
1500	1500	-750	-750	-1.464	-1.464	-1.464	-100	-100
1600	1600	-800	-800	-1.518	-1.518	-1.518	-100	-100
1700	1700	-850	-850	-1.572	-1.572	-1.572	-100	-100
1800	1800	-900	-900	-1.626	-1.626	-1.626	-100	-100
1900	1900	-950	-950	-1.680	-1.680	-1.680	-100	-100
2000	2000	-1000	-1000	-1.734	-1.734	-1.734	-100	-100
2100	2100	-1050	-1050	-1.788	-1.788	-1.788	-100	-100
2200	2200	-1100	-1100	-1.842	-1.842	-1.842	-100	-100
2300	2300	-1150	-1150	-1.896	-1.896	-1.896	-100	-100
2400	2400	-1200	-1200	-1.950	-1.950	-1.950	-100	-100
2500	2500	-1250	-1250	-2.004	-2.004	-2.004	-100	-100
2600	2600	-1300	-1300	-2.058	-2.058	-2.058	-100	-100
2700	2700	-1350	-1350	-2.112	-2.112	-2.112	-100	-100
2800	2800	-1400	-1400	-2.166	-2.166	-2.166	-100	-100
2900	2900	-1450	-1450	-2.220	-2.220	-2.220	-100	-100
3000	3000	-1500	-1500	-2.274	-2.274	-2.274	-100	-100
3100	3100	-1550	-1550	-2.328	-2.328	-2.328	-100	-100
3200	3200	-1600	-1600	-2.382	-2.382	-2.382	-100	-100
3300	3300	-1650	-1650	-2.436	-2.436	-2.436	-100	-100
3400	3400	-1700	-1700	-2.490	-2.490	-2.490	-100	-100
3500	3500	-1750	-1750	-2.544	-2.544	-2.544	-100	-100
3600	3600	-1800	-1800	-2.598	-2.598	-2.598	-100	-100
3700	3700	-1850	-1850	-2.652	-2.652	-2.652	-100	-100
3800	3800	-1900	-1900	-2.706	-2.706	-2.706	-100	-100
3900	3900	-1950	-1950	-2.760	-2.760	-2.760	-100	-100
4000	4000	-2000	-2000	-2.814	-2.814	-2.814	-100	-100
4100	4100	-2050	-2050	-2.868	-2.868	-2.868	-100	-100
4200	4200	-2100	-2100	-2.922	-2.922	-2.922	-100	-100
4300	4300	-2150	-2150	-2.976	-2.976	-2.976	-100	-100
4400	4400	-2200	-2200	-3.030	-3.030	-3.030	-100	-100
4500	4500	-2250	-2250	-3.084	-3.084	-3.084	-100	-100
4600	4600	-2300	-2300	-3.138	-3.138	-3.138	-100	-100
4700	4700	-2350	-2350	-3.192	-3.192	-3.192	-100	-100
4800	4800	-2400	-2400	-3.246	-3.246	-3.246	-100	-100
4900	4900	-2450	-2450	-3.300	-3.300	-3.300	-100	-100
5000	5000	-2500	-2500	-3.354	-3.354	-3.354	-100	-100
5100	5100	-2550	-2550	-3.408	-3.408	-3.408	-100	-100
5200	5200	-2600	-2600	-3.462	-3.462	-3.462	-100	-100
5300	5300	-2650	-2650	-3.516	-3.516	-3.516	-100	-100
5400	5400	-2700	-2700	-3.570	-3.570	-3.570	-100	-100
5500	5500	-2750	-2750	-3.624	-3.624	-3.624	-100	-100
5600	5600	-2800	-2800	-3.678	-3.678	-3.678	-100	-100
5700	5700	-2850	-2850	-3.732	-3.732	-3.732	-100	-100
5800	5800	-2900	-2900	-3.786	-3.786	-3.786	-100	-100
5900	5900	-2950	-2950	-3.840	-3.840	-3.840	-100	-100
6000	6000	-3000	-3000	-3.894	-3.894	-3.894	-100	-100
6100	6100	-3050	-3050	-3.948	-3.948	-3.948	-100	-100
6200	6200	-3100	-3100	-4.002	-4.002	-4.002	-100	-100
6300	6300	-3150	-3150	-4.056	-4.056	-4.056	-100	-100
6400	6400	-3200	-3200	-4.110	-4.110	-4.110	-100	-100
6500	6500	-3250	-3250	-4.164	-4.164	-4.164	-100	-100
6600	6600	-3300	-3300	-4.218	-4.218	-4.218	-100	-100
6700	6700	-3350	-3350	-4.272	-4.272	-4.272	-100	-100
6800	6800	-3400	-3400	-4.326	-4.326	-4.326	-100	-100
6900	6900	-3450	-3450	-4.380	-4.380	-4.380	-100	-100
7000	7000	-3500	-3500	-4.434	-4.434	-4.434	-100	-100
7100	7100	-3550	-3550	-4.488	-4.488	-4.488	-100	-100
7200	7200	-3600	-3600	-4.542	-4.542	-4.542	-100	-100
7300	7300	-3650	-3650	-4.596	-4.596	-4.596	-100	-100
7400	7400	-3700	-3700	-4.650	-4.650	-4.650	-100	-100
7500	7500	-3750	-3750	-4.704	-4.704	-4.704	-100	-100
7600	7600	-3800	-3800	-4.758	-4.758	-4.758	-100	-100
7700	7700	-3850	-3850	-4.812	-4.812	-4.812	-100	-100
7800	7800	-3900	-3900	-4.866	-4.866	-4.866	-100	-100
7900	7900	-3950	-3950	-4.920	-4.920	-4.920	-100	-100
8000	8000	-4000	-4000	-4.974	-4.974	-4.974	-100	-100
8100	8100	-4050	-4050	-5.028	-5.028	-5.028	-100	-100
8200	8200	-4100	-4100	-5.082	-5.082	-5.082	-100	-100
8300	8300	-4150	-4150	-5.136	-5.136	-5.136	-100	-100
8400	8400	-4200	-4200	-5.190	-5.190	-5.190	-100	-100
8500	8500	-4250	-4250	-5.244	-5.244	-5.244	-100	-100
8600	8600	-4300	-4300	-5.298	-5.298	-5.298	-100	-100
8700	8700	-4350	-4350	-5.352	-5.352	-5.352	-100	-100
8800	8800	-4400	-4400	-5.406	-5.406	-5.406	-100	-100
8900	8900	-4450	-4450	-5.460	-5.460	-5.460	-100	-100
9000	9000	-4500	-4500	-5.514	-5.514	-5.514	-100	-100
9100	9100	-4550	-4550	-5.568	-5.568	-5.568	-100	-100
9200	9200	-4600	-4600	-5.622	-5.622	-5.622	-100	-100
9300	9300	-4650	-4650	-5.676	-5.676	-5.676	-100	-100
9400	9400	-4700	-4700	-5.730	-5.730	-5.730	-100	-100
9500	9500	-4750	-4750	-5.784	-5.784	-5.784	-100	-100
9600	9600	-4800	-4800	-5.838	-5.838	-5.838	-100	-100
9700	9700	-4850	-4850	-5.892	-5.892	-5.892	-100	-100
9800	9800	-4900	-4900	-5.946	-5.946	-5.946	-100	-100
9900	9900	-4950	-4950	-6.000	-6.000	-6.000	-100	-100
10000	10000	-5000	-5000	-6.054	-6.054	-6.054	-100	-100

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROCKETTE

E = 10.00	LOAD	EP1	EP2	POISSON'S RATIO, ν	SIGMA MAX	SIGMA MIN	TAU MAX	GAGE NO. 11-OUTSIDE
0	0	0	0	0	0	0	0	0
100	100	-50	-50	-710	-710	-710	0	0
200	200	-100	-50	-1264	-1264	-874	-100	0
300	300	-100	-100	-1924	-1924	-1424	-100	0
400	400	-100	-50	-1264	-1264	-874	-100	0
500	500	-100	-100	-1924	-1924	-1424	-100	0
600	600	-100	-150	-2103	-2103	-2103	100	0
700	700	-100	-150	-1543	-1543	-1478	100	0
800	800	-150	-150	-2103	-2103	-2103	0	0
900	900	-200	-200	-2857	-2857	-2857	0	0
1000	1000	-200	-200	-2308	-2308	-2642	100	0
1100	1100	-200	-250	-3022	-3022	-3007	100	0
1200	1200	-200	-250	-3022	-3022	-3007	100	0
1300	1300	-200	-250	-3022	-3022	-3007	100	0
1400	1400	-200	-250	-3022	-3022	-3007	100	0
1500	1500	-200	-250	-3022	-3022	-3007	100	0
1600	1600	-250	-300	-3736	-3736	-4121	100	0
1700	1700	-250	-350	-3901	-3901	-4670	305	0
1800	1800	-250	-350	-4004	-4004	-5220	577	0
1900	1900	-250	-350	-3901	-3901	-4670	305	0
2000	2000	-250	-350	-3901	-3901	-4670	305	0
2100	2100	-250	-350	-3901	-3901	-4670	305	0
2200	2200	-250	-350	-3901	-3901	-4670	305	0
2300	2300	-250	-350	-3901	-3901	-4670	305	0
2400	2400	-250	-350	-3901	-3901	-4670	305	0
2500	2500	-250	-350	-3901	-3901	-4670	305	0
2600	2600	-250	-350	-3901	-3901	-4670	305	0
2700	2700	-250	-350	-3901	-3901	-4670	305	0
2800	2800	-250	-350	-3901	-3901	-4670	305	0
2900	2900	-250	-350	-3901	-3901	-4670	305	0
3000	3000	-250	-350	-3901	-3901	-4670	305	0
3100	3100	-250	-350	-3901	-3901	-4670	305	0
3200	3200	-250	-350	-3901	-3901	-4670	305	0
3300	3300	-250	-350	-3901	-3901	-4670	305	0
3400	3400	-250	-350	-3901	-3901	-4670	305	0
3500	3500	-250	-350	-3901	-3901	-4670	305	0
3600	3600	-250	-350	-3901	-3901	-4670	305	0
3700	3700	-250	-350	-3901	-3901	-4670	305	0
3800	3800	-250	-350	-3901	-3901	-4670	305	0
3900	3900	-250	-350	-3901	-3901	-4670	305	0
4000	4000	-250	-350	-3901	-3901	-4670	305	0
4100	4100	-250	-350	-3901	-3901	-4670	305	0
4200	4200	-250	-350	-3901	-3901	-4670	305	0
4300	4300	-250	-350	-3901	-3901	-4670	305	0
4400	4400	-250	-350	-3901	-3901	-4670	305	0
4500	4500	-250	-350	-3901	-3901	-4670	305	0
4600	4600	-250	-350	-3901	-3901	-4670	305	0
4700	4700	-250	-350	-3901	-3901	-4670	305	0
4800	4800	-250	-350	-3901	-3901	-4670	305	0
4900	4900	-250	-350	-3901	-3901	-4670	305	0
5000	5000	-250	-350	-3901	-3901	-4670	305	0
5100	5100	-250	-350	-3901	-3901	-4670	305	0
5200	5200	-250	-350	-3901	-3901	-4670	305	0
5300	5300	-250	-350	-3901	-3901	-4670	305	0
5400	5400	-250	-350	-3901	-3901	-4670	305	0
5500	5500	-250	-350	-3901	-3901	-4670	305	0
5600	5600	-250	-350	-3901	-3901	-4670	305	0
5700	5700	-250	-350	-3901	-3901	-4670	305	0
5800	5800	-250	-350	-3901	-3901	-4670	305	0
5900	5900	-250	-350	-3901	-3901	-4670	305	0
6000	6000	-250	-350	-3901	-3901	-4670	305	0
6100	6100	-250	-350	-3901	-3901	-4670	305	0
6200	6200	-250	-350	-3901	-3901	-4670	305	0
6300	6300	-250	-350	-3901	-3901	-4670	305	0
6400	6400	-250	-350	-3901	-3901	-4670	305	0
6500	6500	-250	-350	-3901	-3901	-4670	305	0
6600	6600	-250	-350	-3901	-3901	-4670	305	0
6700	6700	-250	-350	-3901	-3901	-4670	305	0
6800	6800	-250	-350	-3901	-3901	-4670	305	0
6900	6900	-250	-350	-3901	-3901	-4670	305	0
7000	7000	-250	-350	-3901	-3901	-4670	305	0
7100	7100	-250	-350	-3901	-3901	-4670	305	0
7200	7200	-250	-350	-3901	-3901	-4670	305	0
7300	7300	-250	-350	-3901	-3901	-4670	305	0
7400	7400	-250	-350	-3901	-3901	-4670	305	0
7500	7500	-250	-350	-3901	-3901	-4670	305	0
7600	7600	-250	-350	-3901	-3901	-4670	305	0
7700	7700	-250	-350	-3901	-3901	-4670	305	0
7800	7800	-250	-350	-3901	-3901	-4670	305	0
7900	7900	-250	-350	-3901	-3901	-4670	305	0
8000	8000	-250	-350	-3901	-3901	-4670	305	0
8100	8100	-250	-350	-3901	-3901	-4670	305	0
8200	8200	-250	-350	-3901	-3901	-4670	305	0
8300	8300	-250	-350	-3901	-3901	-4670	305	0
8400	8400	-250	-350	-3901	-3901	-4670	305	0
8500	8500	-250	-350	-3901	-3901	-4670	305	0
8600	8600	-250	-350	-3901	-3901	-4670	305	0
8700	8700	-250	-350	-3901	-3901	-4670	305	0
8800	8800	-250	-350	-3901	-3901	-4670	305	0
8900	8900	-250	-350	-3901	-3901	-4670	305	0
9000	9000	-250	-350	-3901	-3901	-4670	305	0
9100	9100	-250	-350	-3901	-3901	-4670	305	0
9200	9200	-250	-350	-3901	-3901	-4670	305	0
9300	9300	-250	-350	-3901	-3901	-4670	305	0
9400	9400	-250	-350	-3901	-3901	-4670	305	0
9500	9500	-250	-350	-3901	-3901	-4670	305	0
9600	9600	-250	-350	-3901	-3901	-4670	305	0
9700	9700	-250	-350	-3901	-3901	-4670	305	0
9800	9800	-250	-350	-3901	-3901	-4670	305	0
9900	9900	-250	-350	-3901	-3901	-4670	305	0
10000	10000	-250	-350	-3901	-3901	-4670	305	0

Table 3C (Continued)
STRAIN REDUCTION OF A TWO GAGE ROSETTE

E = 10,000	LOAD	POISSON'S RATION, .30			SIGMA MAX	SIGMA MIN	GAGE NO. 12-OUTSIDE	
		EP1	EP2	EP3			TAU MAX	TAU MIN
	0	0	0	0	0	0	0	0
	100	-50	-150	-100	-1000	-1010	305	305
	200	-100	-150	-150	-1500	-1510	142	142
	300	-150	-150	-150	-2100	-2100	0	0
	400	-100	-160	-160	-1500	-1500	102	102
	500	-150	-200	-200	-2200	-2200	102	102
	600	-200	-200	-200	-2850	-2850	0	0
	700	-200	-200	-200	-2850	-2850	0	0
	800	-200	-200	-200	-2850	-2850	0	0
	900	-250	-200	-200	-3000	-3020	-102	-102
	1000	-200	-200	-200	-2850	-2850	0	0
	1100	-250	-250	-250	-3500	-3500	0	0
	1200	-300	-200	-200	-3050	-3100	-102	-102
	1300	-300	-250	-250	-3120	-3130	-102	-102
	1400	-300	-250	-250	-3120	-3130	-102	-102
	1500	-350	-250	-250	-3600	-3600	-102	-102
	1600	-400	-250	-250	-5220	-5220	-102	-102
	1700	-400	-300	-300	-5305	-5305	-102	-102
	1800	-400	-300	-300	-5305	-5305	-102	-102
	1900	-400	-300	-300	-5305	-5305	-102	-102
	2000	-400	-300	-300	-5305	-5305	-102	-102
	2100	-400	-300	-300	-5305	-5305	-102	-102
	2200	-400	-300	-300	-5305	-5305	-102	-102
	2300	-400	-300	-300	-5305	-5305	-102	-102
	2400	-400	-300	-300	-5305	-5305	-102	-102
	2500	-400	-300	-300	-5305	-5305	-102	-102
	2600	-400	-300	-300	-5305	-5305	-102	-102
	2700	-400	-300	-300	-5305	-5305	-102	-102
	2800	-400	-300	-300	-5305	-5305	-102	-102
	2900	-400	-300	-300	-5305	-5305	-102	-102
	3000	-400	-300	-300	-5305	-5305	-102	-102
	3100	-400	-300	-300	-5305	-5305	-102	-102
	3200	-400	-300	-300	-5305	-5305	-102	-102
	3300	-400	-300	-300	-5305	-5305	-102	-102
	3400	-400	-300	-300	-5305	-5305	-102	-102
	3500	-400	-300	-300	-5305	-5305	-102	-102
	3600	-400	-300	-300	-5305	-5305	-102	-102
	3700	-400	-300	-300	-5305	-5305	-102	-102
	3800	-400	-300	-300	-5305	-5305	-102	-102
	3900	-400	-300	-300	-5305	-5305	-102	-102
	4000	-400	-300	-300	-5305	-5305	-102	-102
	4100	-400	-300	-300	-5305	-5305	-102	-102
	4200	-400	-300	-300	-5305	-5305	-102	-102
	4300	-400	-300	-300	-5305	-5305	-102	-102
	4400	-400	-300	-300	-5305	-5305	-102	-102
	4500	-400	-300	-300	-5305	-5305	-102	-102
	4600	-400	-300	-300	-5305	-5305	-102	-102
	4700	-400	-300	-300	-5305	-5305	-102	-102
	4800	-400	-300	-300	-5305	-5305	-102	-102
	4900	-400	-300	-300	-5305	-5305	-102	-102
	5000	-400	-300	-300	-5305	-5305	-102	-102

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

Es 10,000	LOAD	EP1	EP2	POISSON'S RATIO = .30	SIGMA MAX	SIGMA MIN	CAGE NO. 8 19-OUTSIDE	YAU MAX
0	0	0	0	0	0	0	0	0
100	100	-50	-100	-0.79	-1029	-1260	102	102
200	200	-100	-200	-1.029	-1029	-1029	0	0
300	300	-150	-150	-2.103	-2103	-2103	0	0
400	400	-100	-100	-1.03	-103	-1070	102	102
500	500	-150	-150	-2.103	-2103	-2103	0	0
600	600	-200	-150	-2.642	-2642	-2300	-102	-102
700	700	-200	-200	-2.653	-2653	-2653	0	0
800	800	-200	-200	-2.657	-2657	-2657	0	0
900	900	-250	-200	-3.017	-3017	-3022	-102	-102
1000	1000	-250	-200	-3.017	-3017	-3022	-102	-102
1100	1100	-300	-200	-3.456	-3456	-3107	-300	-300
1200	1200	-300	-200	-3.456	-3456	-3107	-300	-300
1300	1300	-350	-200	-4.505	-4505	-3352	-577	-577
1400	1400	-350	-200	-4.505	-4505	-3352	-577	-577
1500	1500	-350	-200	-4.505	-4505	-3352	-577	-577
1600	1600	-400	-200	-5.055	-5055	-3616	-764	-764
1700	1700	-400	-200	-5.055	-5055	-3616	-764	-764
1800	1800	-400	-200	-5.055	-5055	-3616	-764	-764
1900	1900	-400	-200	-5.055	-5055	-3616	-764	-764
2000	2000	-400	-200	-5.055	-5055	-3616	-764	-764
2100	2100	-400	-200	-5.055	-5055	-3616	-764	-764
2200	2200	-400	-200	-5.055	-5055	-3616	-764	-764
2300	2300	-400	-200	-5.055	-5055	-3616	-764	-764
2400	2400	-400	-200	-5.055	-5055	-3616	-764	-764
2500	2500	-400	-200	-5.055	-5055	-3616	-764	-764
2600	2600	-400	-200	-5.055	-5055	-3616	-764	-764
2700	2700	-400	-200	-5.055	-5055	-3616	-764	-764
2800	2800	-400	-200	-5.055	-5055	-3616	-764	-764
2900	2900	-400	-200	-5.055	-5055	-3616	-764	-764
3000	3000	-400	-200	-5.055	-5055	-3616	-764	-764
3100	3100	-400	-200	-5.055	-5055	-3616	-764	-764
3200	3200	-400	-200	-5.055	-5055	-3616	-764	-764
3300	3300	-400	-200	-5.055	-5055	-3616	-764	-764
3400	3400	-400	-200	-5.055	-5055	-3616	-764	-764
3500	3500	-400	-200	-5.055	-5055	-3616	-764	-764
3600	3600	-400	-200	-5.055	-5055	-3616	-764	-764
3700	3700	-400	-200	-5.055	-5055	-3616	-764	-764
3800	3800	-400	-200	-5.055	-5055	-3616	-764	-764
3900	3900	-400	-200	-5.055	-5055	-3616	-764	-764
4000	4000	-400	-200	-5.055	-5055	-3616	-764	-764
4100	4100	-400	-200	-5.055	-5055	-3616	-764	-764
4200	4200	-400	-200	-5.055	-5055	-3616	-764	-764
4300	4300	-400	-200	-5.055	-5055	-3616	-764	-764
4400	4400	-400	-200	-5.055	-5055	-3616	-764	-764
4500	4500	-400	-200	-5.055	-5055	-3616	-764	-764
4600	4600	-400	-200	-5.055	-5055	-3616	-764	-764
4700	4700	-400	-200	-5.055	-5055	-3616	-764	-764
4800	4800	-400	-200	-5.055	-5055	-3616	-764	-764
4900	4900	-400	-200	-5.055	-5055	-3616	-764	-764
5000	5000	-400	-200	-5.055	-5055	-3616	-764	-764
5100	5100	-400	-200	-5.055	-5055	-3616	-764	-764
5200	5200	-400	-200	-5.055	-5055	-3616	-764	-764
5300	5300	-400	-200	-5.055	-5055	-3616	-764	-764
5400	5400	-400	-200	-5.055	-5055	-3616	-764	-764
5500	5500	-400	-200	-5.055	-5055	-3616	-764	-764
5600	5600	-400	-200	-5.055	-5055	-3616	-764	-764
5700	5700	-400	-200	-5.055	-5055	-3616	-764	-764
5800	5800	-400	-200	-5.055	-5055	-3616	-764	-764
5900	5900	-400	-200	-5.055	-5055	-3616	-764	-764
6000	6000	-400	-200	-5.055	-5055	-3616	-764	-764
6100	6100	-400	-200	-5.055	-5055	-3616	-764	-764
6200	6200	-400	-200	-5.055	-5055	-3616	-764	-764
6300	6300	-400	-200	-5.055	-5055	-3616	-764	-764
6400	6400	-400	-200	-5.055	-5055	-3616	-764	-764
6500	6500	-400	-200	-5.055	-5055	-3616	-764	-764
6600	6600	-400	-200	-5.055	-5055	-3616	-764	-764
6700	6700	-400	-200	-5.055	-5055	-3616	-764	-764
6800	6800	-400	-200	-5.055	-5055	-3616	-764	-764
6900	6900	-400	-200	-5.055	-5055	-3616	-764	-764
7000	7000	-400	-200	-5.055	-5055	-3616	-764	-764
7100	7100	-400	-200	-5.055	-5055	-3616	-764	-764
7200	7200	-400	-200	-5.055	-5055	-3616	-764	-764
7300	7300	-400	-200	-5.055	-5055	-3616	-764	-764
7400	7400	-400	-200	-5.055	-5055	-3616	-764	-764
7500	7500	-400	-200	-5.055	-5055	-3616	-764	-764
7600	7600	-400	-200	-5.055	-5055	-3616	-764	-764
7700	7700	-400	-200	-5.055	-5055	-3616	-764	-764
7800	7800	-400	-200	-5.055	-5055	-3616	-764	-764
7900	7900	-400	-200	-5.055	-5055	-3616	-764	-764
8000	8000	-400	-200	-5.055	-5055	-3616	-764	-764
8100	8100	-400	-200	-5.055	-5055	-3616	-764	-764
8200	8200	-400	-200	-5.055	-5055	-3616	-764	-764
8300	8300	-400	-200	-5.055	-5055	-3616	-764	-764
8400	8400	-400	-200	-5.055	-5055	-3616	-764	-764
8500	8500	-400	-200	-5.055	-5055	-3616	-764	-764
8600	8600	-400	-200	-5.055	-5055	-3616	-764	-764
8700	8700	-400	-200	-5.055	-5055	-3616	-764	-764
8800	8800	-400	-200	-5.055	-5055	-3616	-764	-764
8900	8900	-400	-200	-5.055	-5055	-3616	-764	-764
9000	9000	-400	-200	-5.055	-5055	-3616	-764	-764
9100	9100	-400	-200	-5.055	-5055	-3616	-764	-764
9200	9200	-400	-200	-5.055	-5055	-3616	-764	-764
9300	9300	-400	-200	-5.055	-5055	-3616	-764	-764
9400	9400	-400	-200	-5.055	-5055	-3616	-764	-764
9500	9500	-400	-200	-5.055	-5055	-3616	-764	-764
9600	9600	-400	-200	-5.055	-5055	-3616	-764	-764
9700	9700	-400	-200	-5.055	-5055	-3616	-764	-764
9800	9800	-400	-200	-5.055	-5055	-3616	-764	-764
9900	9900	-400	-200	-5.055	-5055	-3616	-764	-764
10000	10000	-400	-200	-5.055	-5055	-3616	-764	-764

Table 3C. (Continued).

2. 10.00	LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX	CAGE NO., 1=OUTSIDE
0	0	0	0	0	0	0	
100	-50	-100	-100	-874	-1264	192	
200	-100	-100	-100	-1024	-1424	0	
300	-150	-150	-150	-1593	-1478	192	
400	-100	-100	-150	-1593	-1478	192	
500	-150	-200	-200	-2308	-2642	192	
600	-200	-200	-200	-2505	-8352	1923	
700	-200	-200	-200	-2857	-2857	0	
800	-200	-200	-200	-2857	-2857	0	
900	-250	-250	-250	-3407	-3022	-192	
1000	-250	-250	-250	-3407	-3022	-192	
1100	-300	-300	-200	-3456	-3187	-206	
1200	-300	-300	-200	-3456	-3187	-206	
1300	-350	-350	-250	-4121	-3736	-192	
1400	-350	-350	-250	-4121	-3736	-192	
1500	-400	-400	-250	-4678	-3401	-385	
1600	-400	-400	-250	-5228	-4046	-577	
1700	-400	-400	-250	-5228	-4046	-577	
1800	-450	-450	-300	-5305	-4616	-205	
1900	-450	-450	-250	-5764	-4231	-764	
2000	-450	-450	-250	-5764	-4231	-764	
2100	-500	-500	-250	-5228	-4864	-577	
2200	-500	-500	-250	-5228	-4864	-577	
2300	-550	-550	-200	-4678	-3401	-385	
2400	-550	-550	-200	-4678	-3401	-385	
2500	-600	-600	-150	-3741	-2637	-577	
2600	-600	-600	-150	-3741	-2637	-577	
2700	-650	-650	-100	-3242	-2473	-206	
2800	-650	-650	-100	-3242	-2473	-206	
2900	-700	-700	-100	-2527	-1768	-385	
3000	-700	-700	-100	-2527	-1768	-385	
3100	-750	-750	-50	-2527	-1768	-385	
3200	-750	-750	-50	-2527	-1768	-385	
3300	-800	-800	-50	-1813	-1094	-192	
3400	-800	-800	-50	-1813	-1094	-192	
3500	-850	-850	-50	-1264	-874	-192	
3600	-850	-850	-50	-1264	-874	-192	
3700	-900	-900	-50	-544	-165	-192	
3800	-900	-900	-50	-544	-165	-192	
3900	-950	-950	-50	-544	-165	-192	
4000	-950	-950	-50	-544	-165	-192	
4100	-1000	-1000	-100	-380	-1899	-380	
4200	-1000	-1000	-100	-380	-1899	-380	
4300	-1050	-1050	-100	-504	-165	-192	
4400	-1050	-1050	-100	-504	-165	-192	
4500	-1100	-1100	-100	-504	-165	-192	
4600	-1100	-1100	-100	-504	-165	-192	
4700	-1150	-1150	-100	-504	-165	-192	
4800	-1150	-1150	-100	-504	-165	-192	
4900	-1200	-1200	-100	-504	-165	-192	
5000	-1200	-1200	-100	-504	-165	-192	

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

ϵ_x	ϵ_y	ϵ_{P1}	ϵ_{P2}	POISSON'S RATIO ν	SIGMA MAX	SIGMA MIN	τ_{AU} MAX	CASE NO., ν 1-148102
1000	0	0	0	0	0	0	0	0
2000	-600	-600	-700	-0.19	-0.19	-0.19	10	10
3000	-750	-750	-1750	-0.75	-0.75	-1010	110	110
4000	-1750	-1750	-7750	-0.75	-0.75	-1530	221	221
5000	-1500	-1500	-3550	-0.90	-0.90	-2110	330	330
6000	-1050	-1050	-5000	-1.03	-1.03	-2730	550	550
7000	-2100	-2100	-5100	-2.10	-2.10	-3000	871	871
8000	-2950	-2950	-7300	-2.95	-2.95	-3760	700	700
9000	-3750	-3750	-9500	-3.75	-3.75	-4710	810	810
10000	-4550	-4550	-11500	-4.55	-4.55	-5690	950	950
11000	-5350	-5350	-13500	-5.35	-5.35	-6670	1080	1080
12000	-6150	-6150	-15500	-6.15	-6.15	-7650	1200	1200
13000	-6950	-6950	-17500	-6.95	-6.95	-8630	1320	1320
14000	-7750	-7750	-19500	-7.75	-7.75	-9610	1440	1440
15000	-8550	-8550	-21500	-8.55	-8.55	-10590	1560	1560
16000	-9350	-9350	-23500	-9.35	-9.35	-11570	1680	1680
17000	-10150	-10150	-25500	-10.15	-10.15	-12550	1800	1800
18000	-10950	-10950	-27500	-10.95	-10.95	-13530	1920	1920
19000	-11750	-11750	-29500	-11.75	-11.75	-14510	2040	2040
20000	-12550	-12550	-31500	-12.55	-12.55	-15490	2160	2160
21000	-13350	-13350	-33500	-13.35	-13.35	-16470	2280	2280
22000	-14150	-14150	-35500	-14.15	-14.15	-17450	2400	2400
23000	-14950	-14950	-37500	-14.95	-14.95	-18430	2520	2520
24000	-15750	-15750	-39500	-15.75	-15.75	-19410	2640	2640
25000	-16550	-16550	-41500	-16.55	-16.55	-20390	2760	2760
26000	-17350	-17350	-43500	-17.35	-17.35	-21370	2880	2880
27000	-18150	-18150	-45500	-18.15	-18.15	-22350	3000	3000
28000	-18950	-18950	-47500	-18.95	-18.95	-23330	3120	3120
29000	-19750	-19750	-49500	-19.75	-19.75	-24310	3240	3240
30000	-20550	-20550	-51500	-20.55	-20.55	-25290	3360	3360
0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0
4000	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0
7000	0	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0	0
9000	0	0	0	0	0	0	0	0
10000	0	0	0	0	0	0	0	0
11000	0	0	0	0	0	0	0	0
12000	0	0	0	0	0	0	0	0
13000	0	0	0	0	0	0	0	0
14000	0	0	0	0	0	0	0	0
15000	0	0	0	0	0	0	0	0
16000	0	0	0	0	0	0	0	0
17000	0	0	0	0	0	0	0	0
18000	0	0	0	0	0	0	0	0
19000	0	0	0	0	0	0	0	0
20000	0	0	0	0	0	0	0	0
21000	0	0	0	0	0	0	0	0
22000	0	0	0	0	0	0	0	0
23000	0	0	0	0	0	0	0	0
24000	0	0	0	0	0	0	0	0
25000	0	0	0	0	0	0	0	0
26000	0	0	0	0	0	0	0	0
27000	0	0	0	0	0	0	0	0
28000	0	0	0	0	0	0	0	0
29000	0	0	0	0	0	0	0	0
30000	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0
4000	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0
7000	0	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0	0
9000	0	0	0	0	0	0	0	0
10000	0	0	0	0	0	0	0	0
11000	0	0	0	0	0	0	0	0
12000	0	0	0	0	0	0	0	0
13000	0	0	0	0	0	0	0	0
14000	0	0	0	0	0	0	0	0
15000	0	0	0	0	0	0	0	0
16000	0	0	0	0	0	0	0	0
17000	0	0	0	0	0	0	0	0
18000	0	0	0	0	0	0	0	0
19000	0	0	0	0	0	0	0	0
20000	0	0	0	0	0	0	0	0
21000	0	0	0	0	0	0	0	0
22000	0	0	0	0	0	0	0	0
23000	0	0	0	0	0	0	0	0
24000	0	0	0	0	0	0	0	0
25000	0	0	0	0	0	0	0	0
26000	0	0	0	0	0	0	0	0
27000	0	0	0	0	0	0	0	0
28000	0	0	0	0	0	0	0	0
29000	0	0	0	0	0	0	0	0
30000	0	0	0	0	0	0	0	0

Table 3C (Continued).
STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	SIGMA MAX	SIGMA MIN	TAU MAX	GAGE NO., 2-INSIDE
0	0	0	0	0	0	0
100	-450	-400	-420	-410	-7	0
200	-1200	-1100	-701	-752	019	019
300	-1800	-1650	-1171	-1124	-21	-21
400	-2400	-2200	-1542	-1506	-39	-39
500	-3000	-2800	-1902	-1866	-59	-59
600	-3600	-3350	-2252	-2201	-76	-76
700	-4200	-3950	-2602	-2500	-94	-94
800	-4800	-4550	-2951	-2852	-111	-111
900	-5400	-5150	-3301	-3252	-129	-129
1000	-6000	-5750	-3651	-3602	-146	-146
1100	-6600	-6350	-4001	-3952	-164	-164
1200	-7200	-6950	-4351	-4302	-181	-181
1300	-7800	-7550	-4701	-4652	-199	-199
1400	-8400	-8150	-5051	-5002	-216	-216
1500	-9000	-8750	-5401	-5352	-234	-234
1600	-9600	-9350	-5751	-5702	-251	-251
1700	-10200	-9950	-6101	-6052	-269	-269
1800	-10800	-10550	-6451	-6402	-286	-286
1900	-11400	-11150	-6801	-6752	-304	-304
2000	-12000	-11750	-7151	-7102	-321	-321
2100	-12600	-12350	-7501	-7452	-339	-339
2200	-13200	-12950	-7851	-7802	-356	-356
2300	-13800	-13550	-8201	-8152	-374	-374
2400	-14400	-14150	-8551	-8502	-391	-391
2500	-15000	-14750	-8901	-8852	-409	-409
2600	-15600	-15350	-9251	-9202	-426	-426
2700	-16200	-15950	-9601	-9552	-444	-444
2800	-16800	-16550	-9951	-9902	-461	-461
2900	-17400	-17150	-10301	-10252	-479	-479
3000	-18000	-17750	-10651	-10602	-496	-496
3100	-18600	-18350	-11001	-10952	-514	-514
3200	-19200	-18950	-11351	-11302	-531	-531
3300	-19800	-19550	-11701	-11652	-549	-549
3400	-20400	-20150	-12051	-12002	-566	-566
3500	-21000	-20750	-12401	-12352	-584	-584
3600	-21600	-21350	-12751	-12702	-601	-601
3700	-22200	-21950	-13101	-13052	-619	-619
3800	-22800	-22550	-13451	-13402	-636	-636
3900	-23400	-23150	-13801	-13752	-654	-654
4000	-24000	-23750	-14151	-14102	-671	-671
4100	-24600	-24350	-14501	-14452	-689	-689
4200	-25200	-24950	-14851	-14802	-706	-706
4300	-25800	-25550	-15201	-15152	-724	-724
4400	-26400	-26150	-15551	-15502	-741	-741
4500	-27000	-26750	-15901	-15852	-759	-759
4600	-27600	-27350	-16251	-16202	-776	-776
4700	-28200	-27950	-16601	-16552	-794	-794
4800	-28800	-28550	-16951	-16902	-811	-811
4900	-29400	-29150	-17301	-17252	-829	-829
5000	-30000	-29750	-17651	-17602	-846	-846
5100	-30600	-30350	-18001	-17952	-864	-864
5200	-31200	-30950	-18351	-18302	-881	-881
5300	-31800	-31550	-18701	-18652	-899	-899
5400	-32400	-32150	-19051	-19002	-916	-916
5500	-33000	-32750	-19401	-19352	-934	-934
5600	-33600	-33350	-19751	-19702	-951	-951
5700	-34200	-33950	-20101	-20052	-969	-969
5800	-34800	-34550	-20451	-20402	-986	-986
5900	-35400	-35150	-20801	-20752	-1004	-1004
6000	-36000	-35750	-21151	-21102	-1021	-1021
6100	-36600	-36350	-21501	-21452	-1039	-1039
6200	-37200	-36950	-21851	-21802	-1056	-1056
6300	-37800	-37550	-22201	-22152	-1074	-1074
6400	-38400	-38150	-22551	-22502	-1091	-1091
6500	-39000	-38750	-22901	-22852	-1109	-1109
6600	-39600	-39350	-23251	-23202	-1126	-1126
6700	-40200	-39950	-23601	-23552	-1144	-1144
6800	-40800	-40550	-23951	-23902	-1161	-1161
6900	-41400	-41150	-24301	-24252	-1179	-1179
7000	-42000	-41750	-24651	-24602	-1196	-1196
7100	-42600	-42350	-25001	-24952	-1214	-1214
7200	-43200	-42950	-25351	-25302	-1231	-1231
7300	-43800	-43550	-25701	-25652	-1249	-1249
7400	-44400	-44150	-26051	-26002	-1266	-1266
7500	-45000	-44750	-26401	-26352	-1284	-1284
7600	-45600	-45350	-26751	-26702	-1301	-1301
7700	-46200	-45950	-27101	-27052	-1319	-1319
7800	-46800	-46550	-27451	-27402	-1336	-1336
7900	-47400	-47150	-27801	-27752	-1354	-1354
8000	-48000	-47750	-28151	-28102	-1371	-1371
8100	-48600	-48350	-28501	-28452	-1389	-1389
8200	-49200	-48950	-28851	-28802	-1406	-1406
8300	-49800	-49550	-29201	-29152	-1424	-1424
8400	-50400	-50150	-29551	-29502	-1441	-1441
8500	-51000	-50750	-29901	-29852	-1459	-1459
8600	-51600	-51350	-30251	-30202	-1476	-1476
8700	-52200	-51950	-30601	-30552	-1494	-1494
8800	-52800	-52550	-30951	-30902	-1511	-1511
8900	-53400	-53150	-31301	-31252	-1529	-1529
9000	-54000	-53750	-31651	-31602	-1546	-1546
9100	-54600	-54350	-32001	-31952	-1564	-1564
9200	-55200	-54950	-32351	-32302	-1581	-1581
9300	-55800	-55550	-32701	-32652	-1599	-1599
9400	-56400	-56150	-33051	-33002	-1616	-1616
9500	-57000	-56750	-33401	-33352	-1634	-1634
9600	-57600	-57350	-33751	-33702	-1651	-1651
9700	-58200	-57950	-34101	-34052	-1669	-1669
9800	-58800	-58550	-34451	-34402	-1686	-1686
9900	-59400	-59150	-34801	-34752	-1704	-1704
10000	-60000	-59750	-35151	-35102	-1721	-1721

Table 3C. (Continued)
STRAIN REDUCTION OF A TWO GAGE ROSETTE

LOAD	EP1	EP2	SIGMA MAX	POISSONS RATIO	SIGMA MIN	CAGE NO. 3-INCH	TAU MAX
0	0	0	0	0	0	0	0
100	-400	-400	-342	-0.08	-505	71	71
200	-700	-1500	-600	-0.10	-919	136	136
300	-1000	-2400	-867	-0.12	-1347	200	200
400	-1300	-3300	-1200	-0.14	-1619	266	266
500	-1600	-4200	-1500	-0.16	-2310	340	340
600	-1900	-5100	-1900	-0.18	-2000	450	450
700	-2300	-6100	-2257	-0.20	-3343	543	543
800	-2600	-7000	-2571	-0.22	-3029	629	629
900	-2900	-7900	-2806	-0.24	-4311	710	710
1000	-3250	-8850	-3233	-0.26	-4033	800	800
1100	-3650	-10000	-3609	-0.28	-5457	907	907
1200	-4000	-11000	-3940	-0.30	-5919	1006	1006
1300	-4300	-11900	-4311	-0.32	-6086	1121	1121
1400	-4650	-12800	-4662	-0.34	-7005	1279	1279
1500	-5050	-13800	-5071	-0.36	-7629	1329	1329
1600	-5400	-14800	-5410	-0.38	-8190	1424	1424
1700	-5800	-15800	-5831	-0.40	-8829	1574	1574
1800	-6200	-16800	-6230	-0.42	-9306	1679	1679
1900	-6700	-17800	-6703	-0.44	-11057	1800	1800
2000	-7500	-21000	-7703	-0.46	-11057	2000	2000
1700	-7250	-21200	-7400	-0.48	-11076	1993	1993
1600	-6900	-20300	-7142	-0.50	-10001	1910	1910
1500	-6550	-19450	-6871	-0.52	-10529	1829	1829
1400	-6200	-18650	-6600	-0.54	-10100	1750	1750
1300	-5850	-17800	-6277	-0.56	-9629	1679	1679
1200	-5500	-16950	-5967	-0.58	-9157	1600	1600
1100	-5100	-16050	-5629	-0.60	-8671	1521	1521
1000	-4700	-15100	-5280	-0.62	-8098	1419	1419
900	-4300	-14200	-4940	-0.64	-7619	1336	1336
800	-3950	-13350	-4600	-0.66	-6976	1293	1293
700	-3650	-12500	-4300	-0.68	-6400	1150	1150
600	-3350	-11650	-3900	-0.70	-5776	1093	1093
500	-3050	-10800	-3527	-0.72	-5129	929	929
400	-2700	-9950	-3200	-0.74	-4429	807	807
300	-2300	-9100	-2800	-0.76	-3776	693	693
200	-1900	-8250	-2400	-0.78	-2895	529	529
100	-1550	-7400	-2030	-0.80	-2029	357	357
0	0	0	-1733	-0.82	-1133	200	200
0	0	0	-733	-0.84	-1133	107	107
0	0	0	10	-0.86	224	-107	-107

Table 3C. (Continued).

E _r , %	E _r , %	STRAIN REDUCTION OF A TWO GAGE ROSETTE			POISSONS RATION, ν		GAGE NO. 90-148101	
		2PI	EPD	SIGMA MAX	SIGMA MIN	TAU MAX		
1800	0	-15050	-13050	-9805	-9805	0		
1700	-400	-14550	-12550	-9471	-9400	0		
1600	-1200	-13950	-12050	-9081	-8921	-10		
1500	-2550	-13350	-11550	-8690	-8530	-10		
1400	-3900	-12750	-11050	-8300	-8140	-10		
1300	-5250	-12150	-10550	-7909	-7749	-10		
1200	-6600	-11550	-10050	-7519	-7359	-10		
1100	-7950	-10950	-9550	-7129	-6969	-10		
1000	-9300	-10350	-9050	-6739	-6579	-10		
900	-10650	-9750	-8550	-6349	-6189	-10		
800	-12000	-9150	-8050	-5959	-5799	-10		
700	-13350	-8550	-7550	-5569	-5409	-10		
600	-14700	-7950	-7050	-5179	-5019	-10		
500	-16050	-7350	-6550	-4789	-4629	-10		
400	-17400	-6750	-6050	-4399	-4239	-10		
300	-18750	-6150	-5550	-4009	-3849	-10		
200	-19600	-5550	-5050	-3619	-3459	-10		
100	-20450	-4950	-4550	-3229	-3069	-10		
0	-21300	-4350	-4050	-2839	-2679	-10		
U	-22150	-3750	-3550	-2449	-2289	-10		
	-23000	-3150	-3050	-2059	-1899	-10		
	-23850	-2550	-2450	-1669	-1509	-10		
	-24700	-1950	-1850	-1279	-1119	-10		
	-25550	-1350	-1250	-889	-729	-10		
	-26400	-750	-650	-499	-339	-10		
	-27250	-150	-50	-109	-49	-10		
	-28100	0	0	0	0	-10		
	-28950	0	0	0	0	-10		
	-29800	0	0	0	0	-10		
	-30650	0	0	0	0	-10		
	-31500	0	0	0	0	-10		
	-32350	0	0	0	0	-10		
	-33200	0	0	0	0	-10		
	-34050	0	0	0	0	-10		
	-34900	0	0	0	0	-10		
	-35750	0	0	0	0	-10		
	-36600	0	0	0	0	-10		
	-37450	0	0	0	0	-10		
	-38300	0	0	0	0	-10		
	-39150	0	0	0	0	-10		
	-40000	0	0	0	0	-10		
	-40850	0	0	0	0	-10		
	-41700	0	0	0	0	-10		
	-42550	0	0	0	0	-10		
	-43400	0	0	0	0	-10		
	-44250	0	0	0	0	-10		
	-45100	0	0	0	0	-10		
	-45950	0	0	0	0	-10		
	-46800	0	0	0	0	-10		
	-47650	0	0	0	0	-10		
	-48500	0	0	0	0	-10		
	-49350	0	0	0	0	-10		
	-50200	0	0	0	0	-10		
	-51050	0	0	0	0	-10		
	-51900	0	0	0	0	-10		
	-52750	0	0	0	0	-10		
	-53600	0	0	0	0	-10		
	-54450	0	0	0	0	-10		
	-55300	0	0	0	0	-10		
	-56150	0	0	0	0	-10		
	-57000	0	0	0	0	-10		
	-57850	0	0	0	0	-10		
	-58700	0	0	0	0	-10		
	-59550	0	0	0	0	-10		
	-60400	0	0	0	0	-10		
	-61250	0	0	0	0	-10		
	-62100	0	0	0	0	-10		
	-62950	0	0	0	0	-10		
	-63800	0	0	0	0	-10		
	-64650	0	0	0	0	-10		
	-65500	0	0	0	0	-10		
	-66350	0	0	0	0	-10		
	-67200	0	0	0	0	-10		
	-68050	0	0	0	0	-10		
	-68900	0	0	0	0	-10		
	-69750	0	0	0	0	-10		
	-70600	0	0	0	0	-10		
	-71450	0	0	0	0	-10		
	-72300	0	0	0	0	-10		
	-73150	0	0	0	0	-10		
	-74000	0	0	0	0	-10		
	-74850	0	0	0	0	-10		
	-75700	0	0	0	0	-10		
	-76550	0	0	0	0	-10		
	-77400	0	0	0	0	-10		
	-78250	0	0	0	0	-10		
	-79100	0	0	0	0	-10		
	-79950	0	0	0	0	-10		
	-80800	0	0	0	0	-10		
	-81650	0	0	0	0	-10		
	-82500	0	0	0	0	-10		
	-83350	0	0	0	0	-10		
	-84200	0	0	0	0	-10		
	-85050	0	0	0	0	-10		
	-85900	0	0	0	0	-10		
	-86750	0	0	0	0	-10		
	-87600	0	0	0	0	-10		
	-88450	0	0	0	0	-10		
	-89300	0	0	0	0	-10		
	-90150	0	0	0	0	-10		
	-91000	0	0	0	0	-10		
	-91850	0	0	0	0	-10		
	-92700	0	0	0	0	-10		
	-93550	0	0	0	0	-10		
	-94400	0	0	0	0	-10		
	-95250	0	0	0	0	-10		
	-96100	0	0	0	0	-10		
	-96950	0	0	0	0	-10		
	-97800	0	0	0	0	-10		
	-98650	0	0	0	0	-10		
	-99500	0	0	0	0	-10		
	-100350	0	0	0	0	-10		
	-101200	0	0	0	0	-10		
	-102050	0	0	0	0	-10		
	-102900	0	0	0	0	-10		
	-103750	0	0	0	0	-10		
	-104600	0	0	0	0	-10		
	-105450	0	0	0	0	-10		
	-106300	0	0	0	0	-10		
	-107150	0	0	0	0	-10		
	-108000	0	0	0	0	-10		
	-108850	0	0	0	0	-10		
	-109700	0	0	0	0	-10		
	-110550	0	0	0	0	-10		
	-111400	0	0	0	0	-10		
	-112250	0	0	0	0	-10		
	-113100	0	0	0	0	-10		
	-113950	0	0	0	0	-10		
	-114800	0	0	0	0	-10		
	-115650	0	0	0	0	-10		
	-116500	0	0	0	0	-10		
	-117350	0	0	0	0	-10		
	-118200	0	0	0	0	-10		
	-119050	0	0	0	0	-10		
	-119900	0	0	0	0	-10		
	-120750	0	0	0	0	-10		
	-121600	0	0	0	0	-10		
	-122450	0	0	0	0	-10		
	-123300	0	0	0	0	-10		
	-124150	0	0	0	0	-10		
	-125000	0	0	0	0	-10		
	-125850	0	0	0	0	-10		
	-126700	0	0	0	0	-10		
	-127550	0	0	0	0	-10		
	-128400	0	0	0	0	-10		
	-129250	0	0	0	0	-10		
	-130100	0	0	0	0	-10		
	-130950	0	0	0	0	-10		
	-131800	0	0	0	0	-10		
	-132650	0	0	0	0	-10		
	-133500	0	0	0	0	-10		
	-134350	0	0	0	0	-10		
	-135200	0	0	0	0	-10		
	-136050	0	0	0	0	-10		
	-136900	0	0	0	0	-10		
	-137750	0	0	0	0	-10		
	-138600	0	0	0	0	-10		
	-139450	0	0	0	0	-10		
	-140300	0	0	0	0	-10		
	-141150	0	0	0	0	-10		
	-142000	0	0	0	0	-10		
	-142850	0	0	0	0	-10		
	-143700	0	0	0	0	-10		
	-144550	0	0	0	0	-10		
	-145400	0	0	0	0	-10		
	-146250	0	0	0	0	-10		
	-147100	0	0	0	0	-10		
	-147950	0	0	0	0	-10		
	-148800	0	0	0	0	-10		
	-149650	0	0	0	0	-10		
	-150500	0	0	0	0	-10		
	-151350	0	0	0	0	-10		
	-152200	0	0	0	0	-10		
	-153050	0	0	0	0	-10		
	-153900	0	0	0	0	-10		
	-154750	0	0	0	0	-10		
	-155600	0	0	0	0	-10		
	-156450	0	0	0	0	-10		
	-157300	0	0	0	0	-10		
	-158150	0	0	0	0	-10		
	-159000	0	0	0	0	-10		
	-159850	0	0	0	0	-10		
	-160700	0	0	0	0	-10		
	-161550	0	0	0	0	-10		
	-162400	0	0	0	0	-10		
	-163250	0	0	0	0	-10		
	-164100	0	0	0	0	-10		
	-164950	0	0	0	0	-10		
	-165800	0	0	0	0	-10		
	-166650	0	0	0	0	-10		
	-167500	0	0	0	0	-10		
	-168350	0	0	0	0	-10		
	-169200	0	0	0	0	-10		
	-170050	0	0	0	0	-10		
	-170900	0	0	0	0	-10		
	-171750	0	0	0	0	-10		
	-172600	0	0	0	0	-10		
	-173450	0	0	0	0	-10		
	-174300	0	0	0	0	-10		
	-175150	0	0	0	0	-10		
	-176000	0	0	0	0	-10		
	-176850	0	0	0	0	-10		
	-177700	0	0	0	0	-10		
	-178550	0	0	0	0	-10		
	-179400	0	0	0	0	-10		
	-180250	0	0	0	0	-10		
	-181100	0	0	0	0	-10		
	-181950	0	0	0	0	-10		
	-182800	0	0	0	0	-10		
	-183650	0	0	0	0	-10		
	-184500	0	0	0	0	-10		
	-185350	0	0	0	0	-10		
	-186200	0	0	0	0	-10		
	-187050	0	0	0	0	-10		
	-187900	0	0	0	0	-10		
	-188750	0	0	0	0	-10		
	-189600	0	0	0	0	-10		
	-190450	0	0	0	0	-10		
	-191300	0	0	0	0	-10		
	-192150	0	0	0	0	-10		
	-193000	0	0	0	0	-10		
	-193850	0	0	0	0	-10		
	-194700	0	0	0	0	-10		
	-195550	0	0	0	0	-10		
	-196400	0	0	0	0	-10		
	-197250	0	0	0	0	-10		
	-198100	0	0	0	0	-10		

Table 3C. (Continued).

LOAD	EP1	EP2	POISSONS RATION	Ju	SIGMA MAX	SIGMA MIN	TAU MAX	EAST NO. 5-14-8106
0	0	0				0	0	
100	-50	-50			-719	-719	142	
200	-50	-100			-879	-1409	142	
300	-100	-150			-1593	-1978	142	
400	-200	-200			-3022	-3907	142	
500	-250	-300			-3736	-4121	142	
600	-300	-400			-4615	-5385	305	
700	-350	-450			-5330	-6099	305	
800	-400	-500			-6209	-7363	577	
900	-500	-600			-7473	-8242	305	
1000	-550	-700			-8352	-9505	577	
1100	-600	-800			-9231	-10769	577	
1200	-650	-850			-9945	-11789	709	
1300	-700	-900			-10659	-12710	709	
1400	-750	-950			-11379	-13912	709	
1500	-800	-1050			-12253	-15176	962	
1600	-850	-1100			-12967	-16099	962	
1700	-900	-1150			-13681	-16509	962	
1800	-950	-1250			-14560	-16960	1159	
1900	-950	-1250			-14560	-16960	1159	
1000	-950	-1250			-14560	-16960	1159	
1700	-900	-1200			-13866	-16159	1159	
1600	-850	-1100			-12967	-14960	962	
1500	-800	-1050			-12253	-14176	962	
1400	-750	-950			-11530	-13962	962	
1300	-700	-900			-10659	-12710	709	
1200	-650	-850			-9780	-10939	577	
1100	-550	-750			-8516	-10055	709	
1000	-500	-650			-7637	-8791	577	
900	-450	-600			-6923	-8077	577	
800	-400	-500			-6099	-6813	305	
700	-350	-450			-5330	-6099	305	
600	-300	-400			-4615	-5220	577	
500	-200	-300			-3187	-3956	305	
400	-150	-200			-2380	-2642	142	
300	-100	-150			-1593	-1978	142	
200	-50	-50			-719	-719	142	
100	50	0			140	140	142	
0	50	0			599	165	142	
0	0	-100			-230	-1899	305	

Table 3C. (Continued).
STRAIN REDUCTION OF A TWO GAGE POSITIVE

LOAD	EP1	EP2	POISSONS RATIO = .30	SIGMA MAX	SIGMA MIN	GAGE NO. 2 OUTSIDE TAU MAX
0	0	0	0	0	0	0
100	-50	-100	-0.79	-0.79	-1269	192
200	-150	-150	-2193	-2193	-2193	0
300	-150	-250	-2973	-2973	-3242	305
400	-200	-350	-3352	-3352	-4805	579
500	-300	-500	-4995	-4995	-6980	769
600	-350	-550	-5659	-5659	-7190	769
700	-400	-700	-6703	-6703	-9011	1159
800	-450	-750	-7918	-7918	-9225	1159
900	-550	-850	-8896	-8896	-12154	1159
1000	-600	-950	-9725	-9725	-12010	1396
1100	-700	-1050	-11159	-11159	-13896	1396
1200	-750	-1100	-11860	-11860	-19560	1396
1300	-750	-1150	-12033	-12033	-15110	1530
1400	-800	-1250	-12912	-12912	-16379	1731
1500	-900	-1350	-14391	-14391	-17802	1731
1600	-950	-1400	-15055	-15055	-18916	1731
1700	-1000	-1500	-15430	-15430	-19780	1971
1800	-1050	-1600	-16813	-16813	-21099	2115
1900	-1050	-1900	-18154	-18154	-18896	1996
2000	-1050	-1900	-18154	-18154	-18896	1996
1700	-1000	-1400	-15276	-15276	-17582	1159
1600	-900	-1200	-14396	-14396	-16314	962
1500	-850	-1100	-12967	-12967	-14890	962
1400	-800	-950	-11923	-11923	-13077	977
1300	-750	-850	-11099	-11099	-11013	305
1200	-650	-750	-9615	-9615	-10305	305
1100	-600	-650	-8736	-8736	-9121	192
1000	-550	-550	-7857	-7857	-7857	0
900	-450	-450	-6929	-6929	-6929	0
800	-400	-350	-5599	-5599	-5165	1192
700	-350	-250	-4678	-4678	-3901	305
600	-300	-150	-3791	-3791	-2637	-377
500	-200	0	-2190	-2190	-659	769
400	-150	100	-1319	-1319	609	-962
300	-50	200	110	110	2033	-962
200	0	300	909	909	3297	-2159
100	50	400	1850	1850	9560	-1396
0	50	500	1530	1530	3962	-962
0	-50	2350	7190	7190	24659	-9231

Table 30. (Continued)
STRAIN REDUCTION OF A TWO GAGE ROSETTE

E = 10.00	LOAD	EPI	EP2	POISSONS RATION .30		GAGE NO. 2-INSIDE	
				SIGMA MAX	SIGMA MIN	TAU MAX	TAU MIN
0	0	0	0	0	0	0	0
100	-50	-50	-50	-210	-210	0	0
200	-100	-100	-100	-1020	-1020	0	0
300	-200	-200	-150	-2692	-2300	-102	-102
400	-250	-250	-200	-3987	-3022	-102	-102
500	-350	-350	-250	-6670	-3901	-305	-305
600	-400	-400	-300	-5305	-6015	-305	-305
700	-500	-500	-350	-6608	-5995	-577	-577
800	-550	-550	-400	-7363	-6209	-577	-577
900	-600	-600	-400	-7912	-6179	-769	-769
1000	-700	-700	-450	-9176	-7253	-962	-962
1100	-800	-800	-550	-10600	-8681	-962	-962
1200	-850	-850	-600	-11310	-9396	-962	-962
1300	-900	-900	-650	-12033	-10110	-962	-962
1400	-950	-950	-700	-12797	-10820	-962	-962
1500	-1000	-1000	-750	-13962	-11530	-962	-962
1600	-1050	-1050	-850	-14301	-12002	-769	-769
1700	-1150	-1150	-850	-15990	-13132	-1150	-1150
1800	-1200	-1200	-900	-16159	-13096	-1150	-1150
1900	-1250	-1250	-950	-16868	-13660	-1150	-1150
1000	-1250	-1250	-950	-16868	-13660	-1150	-1150
1700	-1150	-1150	-850	-15990	-13132	-962	-962
1600	-1050	-1050	-750	-14301	-12002	-769	-769
1500	-950	-950	-650	-12797	-10820	-962	-962
1400	-850	-850	-550	-10600	-8681	-962	-962
1300	-700	-700	-400	-7912	-6179	-769	-769
1200	-600	-600	-300	-5305	-6015	-305	-305
1100	-500	-500	-200	-3987	-3022	-102	-102
1000	-400	-400	-100	-2692	-2300	0	0
900	-350	-350	0	-1020	-1020	0	0
800	-300	-300	50	-6670	-3901	0	0
700	-250	-250	50	-5305	-6015	0	0
600	-200	-200	50	-3987	-3022	0	0
500	-150	-150	50	-2692	-2300	0	0
400	-100	-100	50	-1020	-1020	0	0
300	-50	-50	50	-210	-210	0	0
200	0	0	50	0	0	0	0
100	50	50	50	849	849	0	0
0	100	100	100	310	310	0	0
0	50	50	50	165	165	0	0
0	0	0	0	0	0	0	0

Table 3C. (Continued).

LOAD	EP1	EP2	POISSON'S RATION	NU	SIGMA MAX	SIGMA MIN	TAU MAX	CAGE NO. 0 0-148104
0	0	0	0	0	0	0	0	0
100	-50	50	0	-305	305	0	-305	0
200	-150	100	0	-1314	604	0	-604	0
300	-250	150	0	-2253	824	0	-824	0
400	-300	0	0	-2002	654	0	-654	0
500	-400	200	0	-3736	874	0	-874	0
600	-500	250	0	-4467	1044	0	-1044	0
700	-600	250	0	-5764	764	0	-764	0
800	-650	300	0	-6154	1154	0	-1154	0
900	-754	350	0	-7000	1374	0	-1374	0
1000	-850	350	0	-8187	1604	0	-1604	0
1100	-950	350	0	-9284	71	0	-5000	0
1200	-1050	350	0	-10385	305	0	-5305	0
1300	-1000	0	0	-11750	-2527	0	-6115	0
1400	-1000	0	0	-12300	-2640	0	-6000	0
1500	-1250	0	0	-13736	-4121	0	-6000	0
1600	-1300	0	0	-1547	1547	0	-6000	0
1700	-1300	0	0	-1547	1547	0	-6000	0
1800	-1300	0	0	-1547	1547	0	-6000	0
1900	-1300	0	0	-1547	1547	0	-6000	0
2000	-1300	0	0	-1547	1547	0	-6000	0
2100	-1300	0	0	-1547	1547	0	-6000	0
2200	-1300	0	0	-1547	1547	0	-6000	0
2300	-1300	0	0	-1547	1547	0	-6000	0
2400	-1300	0	0	-1547	1547	0	-6000	0
2500	-1300	0	0	-1547	1547	0	-6000	0
2600	-1300	0	0	-1547	1547	0	-6000	0
2700	-1300	0	0	-1547	1547	0	-6000	0
2800	-1300	0	0	-1547	1547	0	-6000	0
2900	-1300	0	0	-1547	1547	0	-6000	0
3000	-1300	0	0	-1547	1547	0	-6000	0
3100	-1300	0	0	-1547	1547	0	-6000	0
3200	-1300	0	0	-1547	1547	0	-6000	0
3300	-1300	0	0	-1547	1547	0	-6000	0
3400	-1300	0	0	-1547	1547	0	-6000	0
3500	-1300	0	0	-1547	1547	0	-6000	0
3600	-1300	0	0	-1547	1547	0	-6000	0
3700	-1300	0	0	-1547	1547	0	-6000	0
3800	-1300	0	0	-1547	1547	0	-6000	0
3900	-1300	0	0	-1547	1547	0	-6000	0
4000	-1300	0	0	-1547	1547	0	-6000	0
4100	-1300	0	0	-1547	1547	0	-6000	0
4200	-1300	0	0	-1547	1547	0	-6000	0
4300	-1300	0	0	-1547	1547	0	-6000	0
4400	-1300	0	0	-1547	1547	0	-6000	0
4500	-1300	0	0	-1547	1547	0	-6000	0
4600	-1300	0	0	-1547	1547	0	-6000	0
4700	-1300	0	0	-1547	1547	0	-6000	0
4800	-1300	0	0	-1547	1547	0	-6000	0
4900	-1300	0	0	-1547	1547	0	-6000	0
5000	-1300	0	0	-1547	1547	0	-6000	0
5100	-1300	0	0	-1547	1547	0	-6000	0
5200	-1300	0	0	-1547	1547	0	-6000	0
5300	-1300	0	0	-1547	1547	0	-6000	0
5400	-1300	0	0	-1547	1547	0	-6000	0
5500	-1300	0	0	-1547	1547	0	-6000	0
5600	-1300	0	0	-1547	1547	0	-6000	0
5700	-1300	0	0	-1547	1547	0	-6000	0
5800	-1300	0	0	-1547	1547	0	-6000	0
5900	-1300	0	0	-1547	1547	0	-6000	0
6000	-1300	0	0	-1547	1547	0	-6000	0
6100	-1300	0	0	-1547	1547	0	-6000	0
6200	-1300	0	0	-1547	1547	0	-6000	0
6300	-1300	0	0	-1547	1547	0	-6000	0
6400	-1300	0	0	-1547	1547	0	-6000	0
6500	-1300	0	0	-1547	1547	0	-6000	0
6600	-1300	0	0	-1547	1547	0	-6000	0
6700	-1300	0	0	-1547	1547	0	-6000	0
6800	-1300	0	0	-1547	1547	0	-6000	0
6900	-1300	0	0	-1547	1547	0	-6000	0
7000	-1300	0	0	-1547	1547	0	-6000	0
7100	-1300	0	0	-1547	1547	0	-6000	0
7200	-1300	0	0	-1547	1547	0	-6000	0
7300	-1300	0	0	-1547	1547	0	-6000	0
7400	-1300	0	0	-1547	1547	0	-6000	0
7500	-1300	0	0	-1547	1547	0	-6000	0
7600	-1300	0	0	-1547	1547	0	-6000	0
7700	-1300	0	0	-1547	1547	0	-6000	0
7800	-1300	0	0	-1547	1547	0	-6000	0
7900	-1300	0	0	-1547	1547	0	-6000	0
8000	-1300	0	0	-1547	1547	0	-6000	0
8100	-1300	0	0	-1547	1547	0	-6000	0
8200	-1300	0	0	-1547	1547	0	-6000	0
8300	-1300	0	0	-1547	1547	0	-6000	0
8400	-1300	0	0	-1547	1547	0	-6000	0
8500	-1300	0	0	-1547	1547	0	-6000	0
8600	-1300	0	0	-1547	1547	0	-6000	0
8700	-1300	0	0	-1547	1547	0	-6000	0
8800	-1300	0	0	-1547	1547	0	-6000	0
8900	-1300	0	0	-1547	1547	0	-6000	0
9000	-1300	0	0	-1547	1547	0	-6000	0
9100	-1300	0	0	-1547	1547	0	-6000	0
9200	-1300	0	0	-1547	1547	0	-6000	0
9300	-1300	0	0	-1547	1547	0	-6000	0
9400	-1300	0	0	-1547	1547	0	-6000	0
9500	-1300	0	0	-1547	1547	0	-6000	0
9600	-1300	0	0	-1547	1547	0	-6000	0
9700	-1300	0	0	-1547	1547	0	-6000	0
9800	-1300	0	0	-1547	1547	0	-6000	0
9900	-1300	0	0	-1547	1547	0	-6000	0
10000	-1300	0	0	-1547	1547	0	-6000	0

Table 3C. (Continued)
STRAIN REDUCTION OF A TWO GAGE ROSETTE

E= 10.00	LOAD	EP1	EP2	POISSONS RATIO= .30	SIGMA MAX	SIGMA MIN	GAGE NO. 0 90-140IDE	TAU MAX
0	0	0	0	0	0	0	0	0
100	-50	-50	-50	-216	-1929	-714	0	0
200	-100	-100	-100	-1929	-1750	-1429	0	0
300	-150	-150	-150	-1750	-1581	-12527	305	305
400	-200	-200	-200	-1581	-1429	-1085	577	577
500	-250	-250	-250	-1429	-1286	-9314	764	764
600	-300	-300	-300	-1286	-1159	-7822	962	962
700	-350	-350	-350	-1159	-1036	-6314	1159	1159
800	-400	-400	-400	-1036	-924	-4822	1346	1346
900	-450	-450	-450	-924	-824	-3314	1536	1536
1000	-500	-500	-500	-824	-736	-1822	1731	1731
1100	-550	-550	-550	-736	-650	-322	1929	1929
1200	-600	-600	-600	-650	-577	-1629	2126	2126
1300	-650	-650	-650	-577	-514	-1029	2326	2326
1400	-700	-700	-700	-514	-450	-429	2526	2526
1500	-750	-750	-750	-450	-396	-282	2726	2726
1600	-800	-800	-800	-396	-346	-132	2926	2926
1700	-850	-850	-850	-346	-302	122	3126	3126
1800	-900	-900	-900	-302	-262	272	3326	3326
1900	-950	-950	-950	-262	-222	422	3526	3526
2000	-1000	-1000	-1000	-222	-182	572	3726	3726
2100	-1050	-1050	-1050	-182	-142	722	3926	3926
2200	-1100	-1100	-1100	-142	-102	872	4126	4126
2300	-1150	-1150	-1150	-102	-62	1022	4326	4326
2400	-1200	-1200	-1200	-62	-22	1172	4526	4526
2500	-1250	-1250	-1250	-22	18	1322	4726	4726
2600	-1300	-1300	-1300	18	68	1472	4926	4926
2700	-1350	-1350	-1350	68	118	1622	5126	5126
2800	-1400	-1400	-1400	118	168	1772	5326	5326
2900	-1450	-1450	-1450	168	218	1922	5526	5526
3000	-1500	-1500	-1500	218	268	2072	5726	5726
3100	-1550	-1550	-1550	268	318	2222	5926	5926
3200	-1600	-1600	-1600	318	368	2372	6126	6126
3300	-1650	-1650	-1650	368	418	2522	6326	6326
3400	-1700	-1700	-1700	418	468	2672	6526	6526
3500	-1750	-1750	-1750	468	518	2822	6726	6726
3600	-1800	-1800	-1800	518	568	2972	6926	6926
3700	-1850	-1850	-1850	568	618	3122	7126	7126
3800	-1900	-1900	-1900	618	668	3272	7326	7326
3900	-1950	-1950	-1950	668	718	3422	7526	7526
4000	-2000	-2000	-2000	718	768	3572	7726	7726
4100	-2050	-2050	-2050	768	818	3722	7926	7926
4200	-2100	-2100	-2100	818	868	3872	8126	8126
4300	-2150	-2150	-2150	868	918	4022	8326	8326
4400	-2200	-2200	-2200	918	968	4172	8526	8526
4500	-2250	-2250	-2250	968	1018	4322	8726	8726
4600	-2300	-2300	-2300	1018	1068	4472	8926	8926
4700	-2350	-2350	-2350	1068	1118	4622	9126	9126
4800	-2400	-2400	-2400	1118	1168	4772	9326	9326
4900	-2450	-2450	-2450	1168	1218	4922	9526	9526
5000	-2500	-2500	-2500	1218	1268	5072	9726	9726
5100	-2550	-2550	-2550	1268	1318	5222	9926	9926
5200	-2600	-2600	-2600	1318	1368	5372	10126	10126
5300	-2650	-2650	-2650	1368	1418	5522	10326	10326
5400	-2700	-2700	-2700	1418	1468	5672	10526	10526
5500	-2750	-2750	-2750	1468	1518	5822	10726	10726
5600	-2800	-2800	-2800	1518	1568	5972	10926	10926
5700	-2850	-2850	-2850	1568	1618	6122	11126	11126
5800	-2900	-2900	-2900	1618	1668	6272	11326	11326
5900	-2950	-2950	-2950	1668	1718	6422	11526	11526
6000	-3000	-3000	-3000	1718	1768	6572	11726	11726
6100	-3050	-3050	-3050	1768	1818	6722	11926	11926
6200	-3100	-3100	-3100	1818	1868	6872	12126	12126
6300	-3150	-3150	-3150	1868	1918	7022	12326	12326
6400	-3200	-3200	-3200	1918	1968	7172	12526	12526
6500	-3250	-3250	-3250	1968	2018	7322	12726	12726
6600	-3300	-3300	-3300	2018	2068	7472	12926	12926
6700	-3350	-3350	-3350	2068	2118	7622	13126	13126
6800	-3400	-3400	-3400	2118	2168	7772	13326	13326
6900	-3450	-3450	-3450	2168	2218	7922	13526	13526
7000	-3500	-3500	-3500	2218	2268	8072	13726	13726
7100	-3550	-3550	-3550	2268	2318	8222	13926	13926
7200	-3600	-3600	-3600	2318	2368	8372	14126	14126
7300	-3650	-3650	-3650	2368	2418	8522	14326	14326
7400	-3700	-3700	-3700	2418	2468	8672	14526	14526
7500	-3750	-3750	-3750	2468	2518	8822	14726	14726
7600	-3800	-3800	-3800	2518	2568	8972	14926	14926
7700	-3850	-3850	-3850	2568	2618	9122	15126	15126
7800	-3900	-3900	-3900	2618	2668	9272	15326	15326
7900	-3950	-3950	-3950	2668	2718	9422	15526	15526
8000	-4000	-4000	-4000	2718	2768	9572	15726	15726
8100	-4050	-4050	-4050	2768	2818	9722	15926	15926
8200	-4100	-4100	-4100	2818	2868	9872	16126	16126
8300	-4150	-4150	-4150	2868	2918	10022	16326	16326
8400	-4200	-4200	-4200	2918	2968	10172	16526	16526
8500	-4250	-4250	-4250	2968	3018	10322	16726	16726
8600	-4300	-4300	-4300	3018	3068	10472	16926	16926
8700	-4350	-4350	-4350	3068	3118	10622	17126	17126
8800	-4400	-4400	-4400	3118	3168	10772	17326	17326
8900	-4450	-4450	-4450	3168	3218	10922	17526	17526
9000	-4500	-4500	-4500	3218	3268	11072	17726	17726
9100	-4550	-4550	-4550	3268	3318	11222	17926	17926
9200	-4600	-4600	-4600	3318	3368	11372	18126	18126
9300	-4650	-4650	-4650	3368	3418	11522	18326	18326
9400	-4700	-4700	-4700	3418	3468	11672	18526	18526
9500	-4750	-4750	-4750	3468	3518	11822	18726	18726
9600	-4800	-4800	-4800	3518	3568	11972	18926	18926
9700	-4850	-4850	-4850	3568	3618	12122	19126	19126
9800	-4900	-4900	-4900	3618	3668	12272	19326	19326
9900	-4950	-4950	-4950	3668	3718	12422	19526	19526
10000	-5000	-5000	-5000	3718	3768	12572	19726	19726

Table 30 (Continued)

ITEM	LOAD	EP1	EP2	POISSON'S RATIO	SIGMA MAX	SIGMA MIN	TAU MAX
10.6C	0	0	0		0	0	
	100	-50	-50		-210	-210	0
	200	-100	-100		-1029	-1029	0
	300	-150	-150		-2103	-2103	0
	400	-200	-200		-2853	-2853	0
	500	-250	-250		-3571	-3571	0
	600	-300	-300		-4286	-4286	0
	700	-350	-350		-5000	-5000	0
	800	-400	-400		-6269	-6269	0
	900	-500	-500		-6978	-6978	-102
	1000	-550	-550		-7853	-7853	-102
	1100	-650	-650		-9121	-9121	-102
	1200	-700	-700		-9286	-9286	-102
	1300	-700	-700		-10000	-10000	0
	1400	-750	-750		-10719	-10719	0
	1500	-800	-800		-11029	-11029	0
	1600	-850	-850		-12193	-12193	0
	1700	-900	-900		-13007	-13007	102
	1800	-950	-1000		-13736	-10121	102
	1900	-900	-900		-12853	-12853	0
	1000	-900	-900		-12853	-12853	0
	1700	-850	-800		-11978	-11593	-102
	1800	-800	-750		-11269	-10879	-102
	1900	-700	-650		-10599	-10165	-102
	1400	-650	-600		-9835	-9451	-102
	1100	-600	-550		-9121	-8736	-102
	1200	-550	-500		-8407	-8022	-102
	1000	-500	-450		-7692	-7308	-102
	900	-450	-400		-6978	-6643	-102
	800	-400	-350		-6269	-5938	-102
	700	-350	-300		-5535	-5215	-102
	600	-300	-250		-4870	-4670	-102
	500	-250	-200		-4207	-4022	-102
	400	-200	-150		-3592	-3473	-102
	300	-150	-100		-3022	-2943	-102
	200	-100	-50		-2500	-2479	-102
	100	-50	0		-2000	-1979	-102
	0	0	50		-1500	-1479	-102
	0	0	0		-1000	-979	-102
	0	0	0		-500	-479	-102
	0	0	0		0	0	0
	0	0	-150		-400	-1600	577

Table 3C (Continued)

STRAIN REDUCTION OF A TWO GAGE ROSETTE

E = 10.00	LOAD	EPI	EP2	POISSON'S RATION .30		EAGE NO. = 11-INCHIDE	
				SIGMA MAX	SIGMA MIN	TAU MAX	TAU MIN
	0	0	0	0	0	0	0
	100	-50	-50	-500	-165	-102	-102
	200	-50	-50	-710	-710	0	0
	300	-100	-100	-1020	-1020	0	0
	400	-200	-200	-2000	-2000	-102	-102
	500	-250	-250	-2500	-2500	-102	-102
	600	-300	-300	-3000	-3000	-102	-102
	700	-350	-350	-3500	-3500	-102	-102
	800	-400	-400	-4000	-4000	0	0
	900	-450	-450	-4500	-4500	0	0
	1000	-500	-500	-5000	-5000	-102	-102
	1100	-550	-550	-5500	-5500	-305	-305
	1200	-600	-600	-6000	-6000	-102	-102
	1300	-650	-650	-6500	-6500	-102	-102
	1400	-700	-700	-7000	-7000	-102	-102
	1500	-750	-750	-7500	-7500	102	102
	1600	-800	-800	-8000	-8000	102	102
	1700	-850	-850	-8500	-8500	102	102
	1800	-900	-900	-9000	-9000	102	102
	1900	-950	-950	-9500	-9500	0	0
	2000	-980	-980	-9800	-9800	0	0
	2100	-980	-980	-9800	-9800	0	0
	2200	-980	-980	-9800	-9800	0	0
	2300	-980	-980	-9800	-9800	0	0
	2400	-980	-980	-9800	-9800	0	0
	2500	-980	-980	-9800	-9800	0	0
	2600	-980	-980	-9800	-9800	0	0
	2700	-980	-980	-9800	-9800	0	0
	2800	-980	-980	-9800	-9800	0	0
	2900	-980	-980	-9800	-9800	0	0
	3000	-980	-980	-9800	-9800	0	0
	3100	-980	-980	-9800	-9800	0	0
	3200	-980	-980	-9800	-9800	0	0
	3300	-980	-980	-9800	-9800	0	0
	3400	-980	-980	-9800	-9800	0	0
	3500	-980	-980	-9800	-9800	0	0
	3600	-980	-980	-9800	-9800	0	0
	3700	-980	-980	-9800	-9800	0	0
	3800	-980	-980	-9800	-9800	0	0
	3900	-980	-980	-9800	-9800	0	0
	4000	-980	-980	-9800	-9800	0	0
	4100	-980	-980	-9800	-9800	0	0
	4200	-980	-980	-9800	-9800	0	0
	4300	-980	-980	-9800	-9800	0	0
	4400	-980	-980	-9800	-9800	0	0
	4500	-980	-980	-9800	-9800	0	0
	4600	-980	-980	-9800	-9800	0	0
	4700	-980	-980	-9800	-9800	0	0
	4800	-980	-980	-9800	-9800	0	0
	4900	-980	-980	-9800	-9800	0	0
	5000	-980	-980	-9800	-9800	0	0
	5100	-980	-980	-9800	-9800	0	0
	5200	-980	-980	-9800	-9800	0	0
	5300	-980	-980	-9800	-9800	0	0
	5400	-980	-980	-9800	-9800	0	0
	5500	-980	-980	-9800	-9800	0	0
	5600	-980	-980	-9800	-9800	0	0
	5700	-980	-980	-9800	-9800	0	0
	5800	-980	-980	-9800	-9800	0	0
	5900	-980	-980	-9800	-9800	0	0
	6000	-980	-980	-9800	-9800	0	0
	6100	-980	-980	-9800	-9800	0	0
	6200	-980	-980	-9800	-9800	0	0
	6300	-980	-980	-9800	-9800	0	0
	6400	-980	-980	-9800	-9800	0	0
	6500	-980	-980	-9800	-9800	0	0
	6600	-980	-980	-9800	-9800	0	0
	6700	-980	-980	-9800	-9800	0	0
	6800	-980	-980	-9800	-9800	0	0
	6900	-980	-980	-9800	-9800	0	0
	7000	-980	-980	-9800	-9800	0	0
	7100	-980	-980	-9800	-9800	0	0
	7200	-980	-980	-9800	-9800	0	0
	7300	-980	-980	-9800	-9800	0	0
	7400	-980	-980	-9800	-9800	0	0
	7500	-980	-980	-9800	-9800	0	0
	7600	-980	-980	-9800	-9800	0	0
	7700	-980	-980	-9800	-9800	0	0
	7800	-980	-980	-9800	-9800	0	0
	7900	-980	-980	-9800	-9800	0	0
	8000	-980	-980	-9800	-9800	0	0
	8100	-980	-980	-9800	-9800	0	0
	8200	-980	-980	-9800	-9800	0	0
	8300	-980	-980	-9800	-9800	0	0
	8400	-980	-980	-9800	-9800	0	0
	8500	-980	-980	-9800	-9800	0	0
	8600	-980	-980	-9800	-9800	0	0
	8700	-980	-980	-9800	-9800	0	0
	8800	-980	-980	-9800	-9800	0	0
	8900	-980	-980	-9800	-9800	0	0
	9000	-980	-980	-9800	-9800	0	0
	9100	-980	-980	-9800	-9800	0	0
	9200	-980	-980	-9800	-9800	0	0
	9300	-980	-980	-9800	-9800	0	0
	9400	-980	-980	-9800	-9800	0	0
	9500	-980	-980	-9800	-9800	0	0
	9600	-980	-980	-9800	-9800	0	0
	9700	-980	-980	-9800	-9800	0	0
	9800	-980	-980	-9800	-9800	0	0
	9900	-980	-980	-9800	-9800	0	0
	10000	-980	-980	-9800	-9800	0	0

Table 30. (Continued).

LOAD	EPI	POISSON'S RATIO, ν		STRAIN REDUCTION OF A TWO GAGE ROSETTE		GAGE NO. 13-18-18-102
		TYPE	SIGMA MAX	SIGMA MIN	TAU MAX	
0	0	0	0	0	0	0
100	-50	-50	-710	-710	0	0
200	-50	-50	-710	-710	0	0
300	-100	-100	-1020	-1020	0	0
400	-150	-150	-1330	-1330	0	0
500	-250	-250	-1640	-1640	0	0
600	-350	-350	-1950	-1950	0	0
700	-450	-450	-2260	-2260	0	0
800	-550	-550	-2570	-2570	0	0
900	-650	-650	-2880	-2880	0	0
1000	-750	-750	-3190	-3190	0	0
1100	-850	-850	-3500	-3500	0	0
1200	-950	-950	-3810	-3810	0	0
1300	-1050	-1050	-4120	-4120	0	0
1400	-1150	-1150	-4430	-4430	0	0
1500	-1250	-1250	-4740	-4740	0	0
1600	-1350	-1350	-5050	-5050	0	0
1700	-1450	-1450	-5360	-5360	0	0
1800	-1550	-1550	-5670	-5670	0	0
1900	-1650	-1650	-5980	-5980	0	0
2000	-1750	-1750	-6290	-6290	0	0
2100	-1850	-1850	-6600	-6600	0	0
2200	-1950	-1950	-6910	-6910	0	0
2300	-2050	-2050	-7220	-7220	0	0
2400	-2150	-2150	-7530	-7530	0	0
2500	-2250	-2250	-7840	-7840	0	0
2600	-2350	-2350	-8150	-8150	0	0
2700	-2450	-2450	-8460	-8460	0	0
2800	-2550	-2550	-8770	-8770	0	0
2900	-2650	-2650	-9080	-9080	0	0
3000	-2750	-2750	-9390	-9390	0	0
3100	-2850	-2850	-9700	-9700	0	0
3200	-2950	-2950	-10010	-10010	0	0
3300	-3050	-3050	-10320	-10320	0	0
3400	-3150	-3150	-10630	-10630	0	0
3500	-3250	-3250	-10940	-10940	0	0
3600	-3350	-3350	-11250	-11250	0	0
3700	-3450	-3450	-11560	-11560	0	0
3800	-3550	-3550	-11870	-11870	0	0
3900	-3650	-3650	-12180	-12180	0	0
4000	-3750	-3750	-12490	-12490	0	0
4100	-3850	-3850	-12800	-12800	0	0
4200	-3950	-3950	-13110	-13110	0	0
4300	-4050	-4050	-13420	-13420	0	0
4400	-4150	-4150	-13730	-13730	0	0
4500	-4250	-4250	-14040	-14040	0	0
4600	-4350	-4350	-14350	-14350	0	0
4700	-4450	-4450	-14660	-14660	0	0
4800	-4550	-4550	-14970	-14970	0	0
4900	-4650	-4650	-15280	-15280	0	0
5000	-4750	-4750	-15590	-15590	0	0
5100	-4850	-4850	-15900	-15900	0	0
5200	-4950	-4950	-16210	-16210	0	0
5300	-5050	-5050	-16520	-16520	0	0
5400	-5150	-5150	-16830	-16830	0	0
5500	-5250	-5250	-17140	-17140	0	0
5600	-5350	-5350	-17450	-17450	0	0
5700	-5450	-5450	-17760	-17760	0	0
5800	-5550	-5550	-18070	-18070	0	0
5900	-5650	-5650	-18380	-18380	0	0
6000	-5750	-5750	-18690	-18690	0	0
6100	-5850	-5850	-19000	-19000	0	0
6200	-5950	-5950	-19310	-19310	0	0
6300	-6050	-6050	-19620	-19620	0	0
6400	-6150	-6150	-19930	-19930	0	0
6500	-6250	-6250	-20240	-20240	0	0
6600	-6350	-6350	-20550	-20550	0	0
6700	-6450	-6450	-20860	-20860	0	0
6800	-6550	-6550	-21170	-21170	0	0
6900	-6650	-6650	-21480	-21480	0	0
7000	-6750	-6750	-21790	-21790	0	0
7100	-6850	-6850	-22100	-22100	0	0
7200	-6950	-6950	-22410	-22410	0	0
7300	-7050	-7050	-22720	-22720	0	0
7400	-7150	-7150	-23030	-23030	0	0
7500	-7250	-7250	-23340	-23340	0	0
7600	-7350	-7350	-23650	-23650	0	0
7700	-7450	-7450	-23960	-23960	0	0
7800	-7550	-7550	-24270	-24270	0	0
7900	-7650	-7650	-24580	-24580	0	0
8000	-7750	-7750	-24890	-24890	0	0
8100	-7850	-7850	-25200	-25200	0	0
8200	-7950	-7950	-25510	-25510	0	0
8300	-8050	-8050	-25820	-25820	0	0
8400	-8150	-8150	-26130	-26130	0	0
8500	-8250	-8250	-26440	-26440	0	0
8600	-8350	-8350	-26750	-26750	0	0
8700	-8450	-8450	-27060	-27060	0	0
8800	-8550	-8550	-27370	-27370	0	0
8900	-8650	-8650	-27680	-27680	0	0
9000	-8750	-8750	-27990	-27990	0	0
9100	-8850	-8850	-28300	-28300	0	0
9200	-8950	-8950	-28610	-28610	0	0
9300	-9050	-9050	-28920	-28920	0	0
9400	-9150	-9150	-29230	-29230	0	0
9500	-9250	-9250	-29540	-29540	0	0
9600	-9350	-9350	-29850	-29850	0	0
9700	-9450	-9450	-30160	-30160	0	0
9800	-9550	-9550	-30470	-30470	0	0
9900	-9650	-9650	-30780	-30780	0	0
10000	-9750	-9750	-31090	-31090	0	0
10100	-9850	-9850	-31400	-31400	0	0
10200	-9950	-9950	-31710	-31710	0	0
10300	-10050	-10050	-32020	-32020	0	0
10400	-10150	-10150	-32330	-32330	0	0
10500	-10250	-10250	-32640	-32640	0	0
10600	-10350	-10350	-32950	-32950	0	0
10700	-10450	-10450	-33260	-33260	0	0
10800	-10550	-10550	-33570	-33570	0	0
10900	-10650	-10650	-33880	-33880	0	0
11000	-10750	-10750	-34190	-34190	0	0
11100	-10850	-10850	-34500	-34500	0	0
11200	-10950	-10950	-34810	-34810	0	0
11300	-11050	-11050	-35120	-35120	0	0
11400	-11150	-11150	-35430	-35430	0	0
11500	-11250	-11250	-35740	-35740	0	0
11600	-11350	-11350	-36050	-36050	0	0
11700	-11450	-11450	-36360	-36360	0	0
11800	-11550	-11550	-36670	-36670	0	0
11900	-11650	-11650	-36980	-36980	0	0
12000	-11750	-11750	-37290	-37290	0	0
12100	-11850	-11850	-37600	-37600	0	0
12200	-11950	-11950	-37910	-37910	0	0
12300	-12050	-12050	-38220	-38220	0	0
12400	-12150	-12150	-38530	-38530	0	0
12500	-12250	-12250	-38840	-38840	0	0
12600	-12350	-12350	-39150	-39150	0	0
12700	-12450	-12450	-39460	-39460	0	0
12800	-12550	-12550	-39770	-39770	0	0
12900	-12650	-12650	-40080	-40080	0	0
13000	-12750	-12750	-40390	-40390	0	0
13100	-12850	-12850	-40700	-40700	0	0
13200	-12950	-12950	-41010	-41010	0	0
13300	-13050	-13050	-41320	-41320	0	0
13400	-13150	-13150	-41630	-41630	0	0
13500	-13250	-13250	-41940	-41940	0	0
13600	-13350	-13350	-42250	-42250	0	0
13700	-13450	-13450	-42560	-42560	0	0
13800	-13550	-13550	-42870	-42870	0	0
13900	-13650	-13650	-43180	-43180	0	0
14000	-13750	-13750	-43490	-43490	0	0
14100	-13850	-13850	-43800	-43800	0	0
14200	-13950	-13950	-44110	-44110	0	0
14300	-14050	-14050	-44420	-44420	0	0
14400	-14150	-14150	-44730	-44730	0	0
14500	-14250	-14250	-45040	-45040	0	0
14600	-14350	-14350	-45350	-45350	0	0
14700	-14450	-14450	-45660	-45660	0	0
14800	-14550	-14550	-45970	-45970	0	0
14900	-14650	-14650	-46280	-46280	0	0
15000	-14750	-14750	-46590	-46590	0	0
15100	-14850	-14850	-46900	-46900	0	0
15200	-14950	-14950	-47210	-47210	0	0
15300	-15050	-15050	-47520	-47520	0	0
15400	-15150	-15150	-47830	-47830	0	0
15500	-15250	-15250	-48140	-48140	0	0
15600	-15350	-15350	-48450	-48450	0	0
15700	-15450	-15450	-48760	-48760	0	0
15800	-15550	-15550	-49070	-49070	0	0
15900	-15650	-15650	-49380	-49380	0	0
16000	-15750	-15750	-49690	-49690	0	0
16100	-15850	-15850	-50000	-50000	0	0
16200	-15950	-15950	-50310	-50310	0	0
16300	-16050	-16050	-50620	-50620	0	0
16400	-16150	-16150	-50930	-50930	0	0
16500	-16250	-16250	-51240	-51240	0	0
16600	-16350	-16350	-51550	-51550	0	0
16700	-16450	-16450	-51860	-51860	0	0
16800	-16550	-16550	-52170	-52170	0	0
16900	-16650	-16650	-52480	-52480	0	0
17000	-16750	-16750	-52790	-52790	0	0
17100	-16850	-16850	-53100	-53100	0	0
17200	-16950	-16950	-53410	-53410	0	0
17300	-17050	-17050	-53720	-53720	0	0
17400	-17150	-17150	-54030	-54030	0	0
17500	-17250	-17250	-54340	-54340	0	0
17600	-17350	-17350	-54650	-54650	0	0
17700	-17450	-17450	-54960	-54960	0	0
17800	-17550	-17550	-55270	-55270	0	0
17900	-17650	-17650	-55580	-55580	0	0
18000	-17750	-17750	-55890	-55890	0	0
18100	-17850	-17850	-56200	-56200	0	0
18200	-17950	-17950	-56510	-56510	0	0
18300	-18050	-18050	-56820	-56820	0	0
18400	-18150</					

Table 34 (continued)

[illegible]

APPENDIX D. DATA FROM FINITE ELEMENT STRESS ANALYSIS OF 66-INCH OD X 58-INCH ID MODEL 2000 NEMO HULL ASSEMBLY

Although the results of the finite element stress analysis for 66-inch OD X 58-inch ID Model 2000 Nemo Hull under 900 psi hydrostatic loading have been summarized in the text of the report (Figures 4 to 8) it was considered desirable to publish this data for the benefit of other plastic hull investigators. The data details the predicted stress and strains for both the top hatch (Figures 1D) and bottom penetration plate (Figure 2D). To correlate the stresses and strains shown on Figures 1D and 2D with physical locations on the Model 2000 Nemo Hull one has only to locate the corresponding node numbers on finite element meshes for top hatch (Figure 5) and bottom penetration plate (Figure 6).

Since the finite element stress analysis was based on the assumption that the stress-strain relationship of acrylic plastic is linear under short term loading in the 0-10,000 psi stress range, the calculated values for 900 psi hydrostatic loading (Figure 1D and 2D) can be extrapolated with reasonable confidence to 1350 psi hydrostatic loading representing the 3000 foot operational depth of the Model 2000 Nemo Hull. For hydrostatic loadings in excess of 1500 psi the extrapolation of values calculated for 900 psi is not recommended as the stress-strain relationship for acrylic plastic becomes non-linear at the stress values encountered in this loading range.

UPPER MATCH
10-1-84
100000

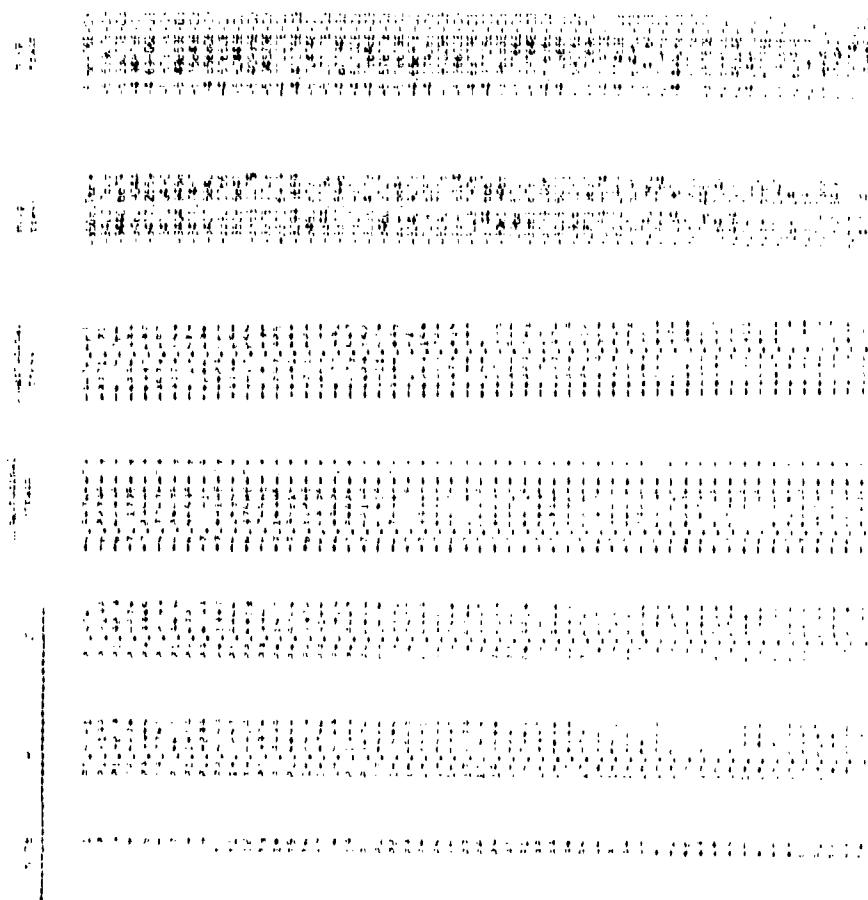


Figure 10. Predicted stress and strains for the top hatch.

UPPER WATCH
MODES 55-116

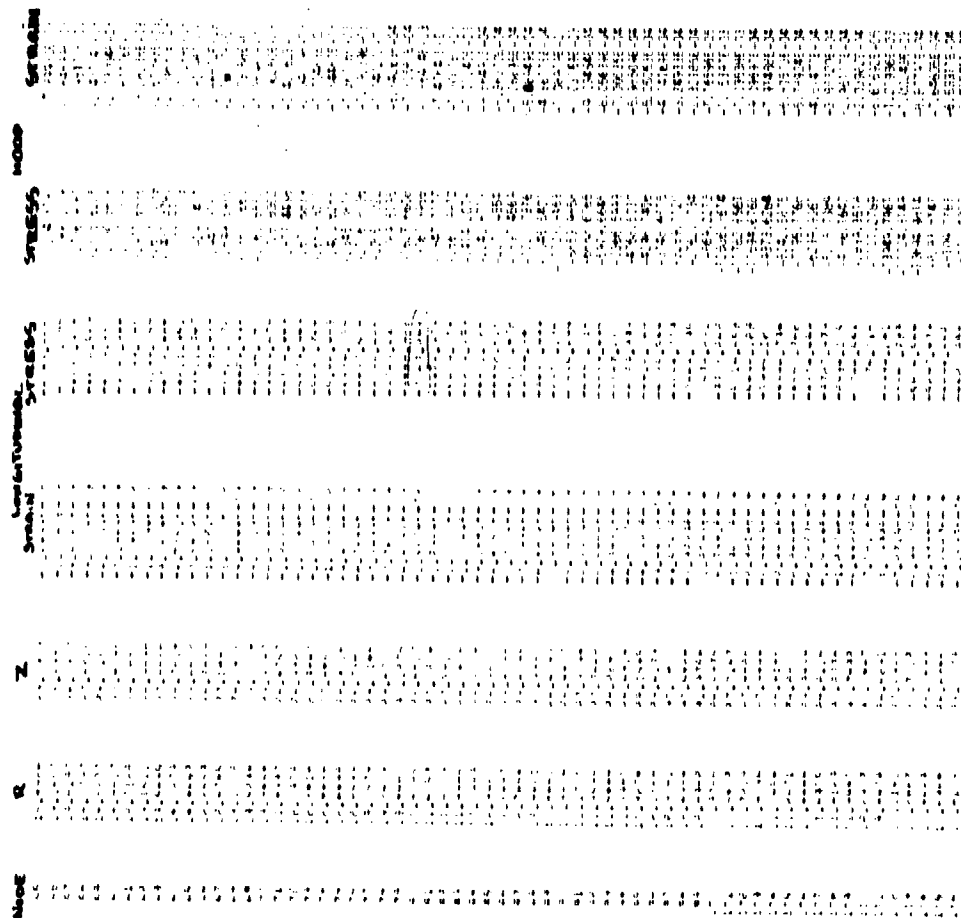


Figure 10. (Continued)

NOON	R	Z	ORIGIN	LOWEST ALTITUDE	STATION	STATION
117	10.0000	20.0000	00.0000	00.0000	00.0000	00.0000
118	11.0000	10.0000	01.0000	01.0000	01.0000	01.0000
119	12.0000	00.0000	02.0000	02.0000	02.0000	02.0000
120	13.0000	00.0000	03.0000	03.0000	03.0000	03.0000
121	14.0000	00.0000	04.0000	04.0000	04.0000	04.0000
122	15.0000	00.0000	05.0000	05.0000	05.0000	05.0000
123	16.0000	00.0000	06.0000	06.0000	06.0000	06.0000
124	17.0000	00.0000	07.0000	07.0000	07.0000	07.0000
125	18.0000	00.0000	08.0000	08.0000	08.0000	08.0000
126	19.0000	00.0000	09.0000	09.0000	09.0000	09.0000
127	20.0000	00.0000	10.0000	10.0000	10.0000	10.0000
128	21.0000	00.0000	11.0000	11.0000	11.0000	11.0000
129	22.0000	00.0000	12.0000	12.0000	12.0000	12.0000
130	23.0000	00.0000	13.0000	13.0000	13.0000	13.0000
131	24.0000	00.0000	14.0000	14.0000	14.0000	14.0000
132	25.0000	00.0000	15.0000	15.0000	15.0000	15.0000
133	26.0000	00.0000	16.0000	16.0000	16.0000	16.0000
134	27.0000	00.0000	17.0000	17.0000	17.0000	17.0000
135	28.0000	00.0000	18.0000	18.0000	18.0000	18.0000
136	29.0000	00.0000	19.0000	19.0000	19.0000	19.0000
137	30.0000	00.0000	20.0000	20.0000	20.0000	20.0000
138	31.0000	00.0000	21.0000	21.0000	21.0000	21.0000
139	32.0000	00.0000	22.0000	22.0000	22.0000	22.0000
140	33.0000	00.0000	23.0000	23.0000	23.0000	23.0000
141	34.0000	00.0000	24.0000	24.0000	24.0000	24.0000
142	35.0000	00.0000	25.0000	25.0000	25.0000	25.0000
143	36.0000	00.0000	26.0000	26.0000	26.0000	26.0000
144	37.0000	00.0000	27.0000	27.0000	27.0000	27.0000
145	38.0000	00.0000	28.0000	28.0000	28.0000	28.0000
146	39.0000	00.0000	29.0000	29.0000	29.0000	29.0000
147	40.0000	00.0000	30.0000	30.0000	30.0000	30.0000
148	41.0000	00.0000	31.0000	31.0000	31.0000	31.0000
149	42.0000	00.0000	32.0000	32.0000	32.0000	32.0000
150	43.0000	00.0000	33.0000	33.0000	33.0000	33.0000
151	44.0000	00.0000	34.0000	34.0000	34.0000	34.0000
152	45.0000	00.0000	35.0000	35.0000	35.0000	35.0000
153	46.0000	00.0000	36.0000	36.0000	36.0000	36.0000
154	47.0000	00.0000	37.0000	37.0000	37.0000	37.0000
155	48.0000	00.0000	38.0000	38.0000	38.0000	38.0000
156	49.0000	00.0000	39.0000	39.0000	39.0000	39.0000
157	50.0000	00.0000	40.0000	40.0000	40.0000	40.0000
158	51.0000	00.0000	41.0000	41.0000	41.0000	41.0000
159	52.0000	00.0000	42.0000	42.0000	42.0000	42.0000
160	53.0000	00.0000	43.0000	43.0000	43.0000	43.0000
161	54.0000	00.0000	44.0000	44.0000	44.0000	44.0000
162	55.0000	00.0000	45.0000	45.0000	45.0000	45.0000
163	56.0000	00.0000	46.0000	46.0000	46.0000	46.0000
164	57.0000	00.0000	47.0000	47.0000	47.0000	47.0000
165	58.0000	00.0000	48.0000	48.0000	48.0000	48.0000
166	59.0000	00.0000	49.0000	49.0000	49.0000	49.0000
167	60.0000	00.0000	50.0000	50.0000	50.0000	50.0000
168	61.0000	00.0000	51.0000	51.0000	51.0000	51.0000
169	62.0000	00.0000	52.0000	52.0000	52.0000	52.0000
170	63.0000	00.0000	53.0000	53.0000	53.0000	53.0000
171	64.0000	00.0000	54.0000	54.0000	54.0000	54.0000
172	65.0000	00.0000	55.0000	55.0000	55.0000	55.0000
173	66.0000	00.0000	56.0000	56.0000	56.0000	56.0000
174	67.0000	00.0000	57.0000	57.0000	57.0000	57.0000
175	68.0000	00.0000	58.0000	58.0000	58.0000	58.0000
176	69.0000	00.0000	59.0000	59.0000	59.0000	59.0000
177	70.0000	00.0000	60.0000	60.0000	60.0000	60.0000
178	71.0000	00.0000	61.0000	61.0000	61.0000	61.0000

UPPER MATH
MORSE W-170

Figure 1D. (Continued).

NODE	R	Z	LONGITUDE (DEG)	STRESS (PSI)	DEEP (FT)	ORIGIN
1	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
26	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
29	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
32	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
37	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
38	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
41	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
42	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
43	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
44	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
45	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
46	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
47	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
49	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
51	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
52	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
53	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
54	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
56	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
57	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
59	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

UPPER HATCH
NODES 179-210

Figure 1D. (Continued).

LOWER PLATE
MODELS 1-54

11-7

NODE	R	Z	Local Nodal Degrees of Freedom	Global Node	Global Node
65	10.4000	27.2000	1.00000000	1.00000000	1.00000000
66	10.4000	27.2000	1.00000000	1.00000000	1.00000000
67	10.4000	27.2000	1.00000000	1.00000000	1.00000000
68	10.4000	27.2000	1.00000000	1.00000000	1.00000000
69	10.4000	27.2000	1.00000000	1.00000000	1.00000000
70	10.4000	27.2000	1.00000000	1.00000000	1.00000000
71	10.4000	27.2000	1.00000000	1.00000000	1.00000000
72	10.4000	27.2000	1.00000000	1.00000000	1.00000000
73	10.4000	27.2000	1.00000000	1.00000000	1.00000000
74	10.4000	27.2000	1.00000000	1.00000000	1.00000000
75	10.4000	27.2000	1.00000000	1.00000000	1.00000000
76	10.4000	27.2000	1.00000000	1.00000000	1.00000000
77	10.4000	27.2000	1.00000000	1.00000000	1.00000000
78	10.4000	27.2000	1.00000000	1.00000000	1.00000000
79	10.4000	27.2000	1.00000000	1.00000000	1.00000000
80	10.4000	27.2000	1.00000000	1.00000000	1.00000000
81	10.4000	27.2000	1.00000000	1.00000000	1.00000000
82	10.4000	27.2000	1.00000000	1.00000000	1.00000000
83	10.4000	27.2000	1.00000000	1.00000000	1.00000000
84	10.4000	27.2000	1.00000000	1.00000000	1.00000000
85	10.4000	27.2000	1.00000000	1.00000000	1.00000000
86	10.4000	27.2000	1.00000000	1.00000000	1.00000000
87	10.4000	27.2000	1.00000000	1.00000000	1.00000000
88	10.4000	27.2000	1.00000000	1.00000000	1.00000000
89	10.4000	27.2000	1.00000000	1.00000000	1.00000000
90	10.4000	27.2000	1.00000000	1.00000000	1.00000000
91	10.4000	27.2000	1.00000000	1.00000000	1.00000000
92	10.4000	27.2000	1.00000000	1.00000000	1.00000000
93	10.4000	27.2000	1.00000000	1.00000000	1.00000000
94	10.4000	27.2000	1.00000000	1.00000000	1.00000000
95	10.4000	27.2000	1.00000000	1.00000000	1.00000000
96	10.4000	27.2000	1.00000000	1.00000000	1.00000000
97	10.4000	27.2000	1.00000000	1.00000000	1.00000000
98	10.4000	27.2000	1.00000000	1.00000000	1.00000000
99	10.4000	27.2000	1.00000000	1.00000000	1.00000000
100	10.4000	27.2000	1.00000000	1.00000000	1.00000000
101	10.4000	27.2000	1.00000000	1.00000000	1.00000000
102	10.4000	27.2000	1.00000000	1.00000000	1.00000000
103	10.4000	27.2000	1.00000000	1.00000000	1.00000000
104	10.4000	27.2000	1.00000000	1.00000000	1.00000000
105	10.4000	27.2000	1.00000000	1.00000000	1.00000000
106	10.4000	27.2000	1.00000000	1.00000000	1.00000000
107	10.4000	27.2000	1.00000000	1.00000000	1.00000000
108	10.4000	27.2000	1.00000000	1.00000000	1.00000000
109	10.4000	27.2000	1.00000000	1.00000000	1.00000000
110	10.4000	27.2000	1.00000000	1.00000000	1.00000000
111	10.4000	27.2000	1.00000000	1.00000000	1.00000000
112	10.4000	27.2000	1.00000000	1.00000000	1.00000000
113	10.4000	27.2000	1.00000000	1.00000000	1.00000000
114	10.4000	27.2000	1.00000000	1.00000000	1.00000000
115	10.4000	27.2000	1.00000000	1.00000000	1.00000000
116	10.4000	27.2000	1.00000000	1.00000000	1.00000000

LOWER PLATE
NODES 55-116

Figure 2D. (Continued).

NODE	R	Z	ORIGINAL COORDINATES	STRESS	DISPLACEMENT	STRESS
179	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
180	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
181	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
182	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
183	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
184	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
185	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
186	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
187	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
188	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
189	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
190	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
191	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
192	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
193	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
194	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
195	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
196	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
197	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
198	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
199	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
200	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
201	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
202	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
203	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
204	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
205	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
206	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
207	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
208	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
209	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
210	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
211	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
212	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
213	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
214	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
215	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
216	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
217	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
218	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
219	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
220	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
221	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
222	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
223	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
224	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
225	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
226	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
227	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
228	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000

LOWER PLATE
NODES 179-228

Figure 2D. (Continued).